EIGHTH ANNUAL REPORT

OF THE

PENNSYLVANIA

DEPARTMENT OF AGRICULTURE.

PART I.

1902.

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1903.

VIRTUE LIBERTY AND INDEPENDENCE

PENNSYLVANIA DEPARTMENT OF AGRICULTURE.

OFFICIAL LIST.

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1—6—1902

ANNUAL REPORT

OF THE

SECRETARY OF AGRICULTURE.

HARRISBURG, PA., *January 1, 1903.*

Hon. WILLIAM A. STONE, *Governor of Pennsylvania :*

Sir: In compliance with the requirements of Sections 2, 3 and 6 of the act of Legislature of March 13th, 1895, establishing this Department, I have the honor to present herewith my Annual Report for the year 1902, being the Eighth Annual Report of the Department of Agriculture of Pennsylvania.

The act creating the Department declares how it shall be organized and defines the scope of its work. The Department has now had eight years of existence, and its work has increased from a mere beginning to its present proportions, extending its influence to all parts of the State, and to dealing with agriculture in all of its relations to the farmer, and to the educational and commercial interests that affect his calling. Whilst the amount of work done, and to be done, increases continually, yet as the officers of the Department gain in experience and information, they are able, with the same effort, to accomplish much more each succeeding year.

The time ought never to arrive when the operations of the Department of Agriculture of Pennsylvania will fall into mere routine. Its officers are dealing, face to face, with powerful living forces, many of whose operations are as yet imperfectly understood, but which are never ceasing in their activity, and affect for good or ill the interests of agriculture, and often increase or diminish its pro-

duction to an extent impossible to compute. A single insect suddenly appears by myriads and completely overruns entire States; a fungus growth multiplies in such enormous numbers as to blight and completely destroy whole crops in a single week. The germs of disease fill the atmosphere, and finding their way to the vital organs of animal life, sweep the country clear of cattle. Food products are doctored with substances injurious to health, whose identity only the most skillful and painstaking microscopist or chemical examiner can detect. Beverages are doctored with poisons to simulate the flavor of wholesome drinks, or to conceal the decomposition that has already begun.

Whoever else may settle down to the stupor of routine, the Department of Agriculture cannot, if it is to fulfill its mission and do the work which it was created to perform. Its vigilance cannot be relaxed for a single moment. Unceasing, indefatigable work must characterize its officers and employes. The Department must keep informed with regard to the latest and most reliable discoveries in the scientific world, which affect agricultural people, or their industry in any of its parts, and must promptly disseminate this knowledge throughout the State. It must keep in touch with educational institutions, agricultural organizations, workers and experts in other States and in foreign countries. It must, in short, be a great information-giving bureau, intelligent and ever active; collecting and sending forth reliable data for public use, correcting false impressions and condemning ill-judged practices where they exist.

To properly meet these demands the best service that the most capable possess is required.

The Department force has become familiar with the performance of the several duties with which each is entrusted, and the work of the several Divisions is, therefore, more satisfactory than ever before. Division officers, attorneys, agents, chemists, inspectors, clerks and messengers have come to know what is expected, and they are able to promptly and effectively perform their respective duties.

CROPS.

The general condition and yield of the crops during the year, have been about an average. Wheat was affected by early drouth, but afterwards had abundance of moisture. The rains continued through harvest, and a good deal of wheat was injured by sprouting. The yield, however, is above expectation.

Corn in middle and western Pennsylvania, was caught by the early September frosts and a large amount of immature and soft corn is the result.

Oats was a good crop. Potatoes rotted considerably in many sections. The late crop is of good size and quality.

Hay was short, but the rains during and after harvest, brought forward the second crop to exceed the first in quantity.

Tobacco has proved a fairly good crop and was housed in good condition.

The apple crop was large in some sections, and of good quality. Peaches were only a partial crop. Pears were plenty, well developed and of good flavor.

Prices of farm produce and wages have been maintained, as will be seen, by reference to the table presented elsewhere in this report.

FARM HELP.

The securing of efficient farm help is becoming more and more serious each year. The wonderful development of the manufacturing, mining, commercial and transportation industries, has drained the country of help until, in some localities, it is impossible to hire labor at any price which the farmer can afford to pay. More women have been working in the fields this year, than perhaps ever before in the history of the State.

In suggesting a solution of this problem, I can only reiterate that which was stated in my report last year, viz: "Smaller farms, gang plows, wider harrows, mowers, horse rakes and drills; fast walking horses; conveniences for the watering, feeding and stabling of animals, and, in general, economy of effort in every direction."

It is also becoming a question, as to whether we should not return to the grazing and feeding of animals more extensively than we are now doing. This system of husbandry economizes labor, and if judiciously pursued, will be as remunerative, in the end, as many of the methods, which require greater expenditure of effort, and a larger force of hired help. The supply of first class beef is not likely to be greater than the demand, for years to come, and Pennsylvania is well adapted, in most of its area, to beef production. The rearing of beef, swine, poultry, sheep and horses suggests, therefore, a means of at least temporary relief, from the burden of labor which is now imposed upon the Pennsylvania farmer, and at the same time increases the fertility of his land, through the manufacture of barnyard manure from the feeding, at home, of crops raised upon the farm.

DOMESTIC HELP.

The same dearth of help which embarrasses the farmer in caring for his crops, is found in securing domestic help to assist in his home.

So many avenues of occupation are now open to women, which require only from six to eight, or at most, ten hours, of their time in a day, after which they are at liberty to do as they please, that

many prefer this life, to domestic service. This freedom, and the comradery and equality of young women, which comes from being engaged in a common occupation, accounts, more than the price which they receive for this labor, for their preferring factory or store service, to that of life in a farm home. Whatever the cause, the fact is, that young girls do leave for other lines of occupation, and the country housewife is obliged to do the work, and care for her children, unassisted by hired help. For this there seems to be no relief, except to simplify living, introduce improvements in the arrangement of the interiors of homes, and adopt labor-saving appliances that will reduce steps and save strength. The difficulty, therefore, in securing labor, available when needed, both for farm work and domestic service, has become a most serious obstacle in the way of profitable agriculture.

CLASSIFICATION OF THE DEPARTMENT WORK.

The work of the Department is distributed among its various Divisions, and each Division, through its official head, is entrusted with the carrying out of all the details of the duties assigned. The following summary, shows the classification:

DIVISION OF FARMERS' INSTITUTES. The work of this Di vision is educational, carrying information to the districts in which the farmers' live, and reached during the past year about one hundred and forty-four thousand farming people.

CROP REPORTS. The system of crop reports is made part of the work of the Institute Division. Careful reporters are engaged in collecting data for the Department in every county in the State. These data are then arranged and published in the Annual Report.

THE DAIRY AND FOOD DIVISION. This Division is under the immediate supervision and direction of a Dairy and Food Commissioner, who is charged with the enforcement of the laws relating to the inspection of the character of the various foods on sale in the State, and the prosecution of those who are found violating the law. The Commissioner has charge also of the Dairy industry of the State, including dairy statistics and improved management of creameries and dairy herds.

DIVISION OF ECONOMIC ZOOLOGY. This Division is in charge of a Commissioner who is known as the The Economic Zoologist, whose duties are to make examination and investigations into

the insect enemies of crops and report upon their ravages and give suggestions for their control or eradication. There is assigned to this Division the Orchard, Greenhouse, Market Garden and Flower Gardening industries of the State. Information is sent out by him to those engaged in these industries, giving the latest scientific and practical discoveries in these lines of work, and as new questions arise he endeavors to have investigations made and proper solution discovered to meet the new conditions.

DIVISION OF VETERINARY SCIENCE. The chief of this Division is by law, required to be "a graduate of some reputable veterinary college." The law further makes it the duty of the Secretary of Agriculture "to obtain and distribute information on all matters relating to the raising and care of stock and poultry; the best methods of producing wool and preparing the same for market." This work is consigned to the Veterinary Division. The Veterinarian is also a member of the State Live Stock Sanitary Board, whose duty it is to "protect the health of the domestic animals of the State," and powers to adopt means to effect this are granted by the act creating the Board.

FERTILIZER INSPECTION AND ANALYSES. The work of the licensing and inspection of Commercial Fertilizers is in the hands of the Secretary. Agents are employed to collect samples of goods upon the market, and these are transmitted to the chemists for analyses. The results are published for the information of farmers and dealers, twice each year.

INSPECTION OF NURSERIES. The Legislature of 1901 passed an act making it the duty of the Secretary of Agriculture "to cause an examination to be made each year of each and every nursery or other places in this State where trees, shrubs, vines or plants, commonly known as nursery stock, are grown for sale, for the purpose of ascertaining whether the trees, shrubs, vines or plants, therein kept or propagated for sale, are infested with San José Scale or other insect pest destructive of such trees, shrubs, vines or plants." Where a nursery is free from these insect pests, a certificate stating the fact is issued to the owner.

CONCENTRATED COMMERCIAL FEEDING STUFFS. Under the act of 25th of April, 1901, all concentrated commercial feeding stuffs sold in this State, such as "linseed meals, cottonseed meals, gluten meals, maize feeds, starch feeds, sugar feeds, dried brewers' grains, malt sprouts, hominy foods, cerealine feeds, rice meals, ground beef or fish scraps, and all materials of similar nature," must have affixed to the package containing them a label "certifying the number of net pounds of feeding stuff contained therein; the name, brand or trade mark under which the article is sold; the name and address of the manufacturer or importer, and a statement of the

percentages it contains of crude fat and crude protein." The Secretary of Agriculture is charged with the enforcement of this law.

LINSEED OIL INSPECTION. The act of 23d of April, A. D. 1901, provides "That no person, firm or corporation shall manufacture or mix for sale, sell or offer for sale, under the name of raw linseed oil, any article which is not wholly the product of commercially pure linseed or flaxseed. Nor shall any person, firm or corporation manufacture or mix for sale, sell or offer for sale, under the name of boiled linseed oil, any article unless the oil from which said article is made, be wholly the product of commercially pure linseed or flaxseed, and unless the same has been heated to at least two hundred and twenty five degrees, Fahrenheit." The Secretary of Agriculture is charged with the enforcement of this law.

SPECIAL INVESTIGATIONS. The law creating the Department provides for "the employment of experts to make special examinations and investigations." These experts are selected by the Secretary, and the results of their examinations are printed either in special Bulletins or in the Annual Report. The investigations are upon subjects relating to the agricultural industry.

BULLETINS. The Secretary is also directed to "publish from time to time such bulletins of information as he may deem useful and advisable, the number not to exceed five thousand copies of any one bulletin." One hundred and six such publications have been issued since 1895.

ANNUAL REPORT. Each year the Secretary is directed to "make an Annual Report to the Governor," and in this report "he may include so much of the reports of other organizations as he shall deem proper." Thirty-one thousand six hundred copies are authorized to be distributed; 9,000 to the Senate, 20,000 to the House of Representatives, 2,000 copies to the Secretary of Agriculture, 500 copies to the State Librarian, and to the State Experiment Station, 100 copies.

BOOKS OF ACCOUNT. The General Books of Account of the Department are in charge of the Secretary, and the Special Books are in charge of the several Division officers.

REPORTS OF DIVISION OFFICERS. Monthly reports of the operation of each Division for the preceding month are made to the Secretary by the chief of each Division, and special reports from time to time are made as may be necessary in order to keep the Secretary fully informed as to the work of the several Divisions. At the close of the year, full reports of the work of each Division are made out and transmitted to the Secretary, and printed in the Annual Report of the Department. The care of the library, the reading of proof, and the mailing lists, are in charge of the Chief Clerk.

DIVISION OF FARMERS' INSTITUTES.

Farmers' Institutes in this country, in the sense of their consisting of assemblages of farmers, met for the discussion of agricultural topics, extend as far back as the organization of the Philadelphia Society for the Promotion of Agriculture in 1785. Later, in other States similar agricultural societies and farm clubs took up, in some degree, the same methods for the improvement of their members.

It was not, however, until quite recently that any well organized or carefully planned system of farmers' institutes has existed. In Pennsylvania, the first modern institute was held in 1877, under the direction of the State Board of Agriculture, and it was not until 1885, when the State made an appropriation for their maintenance, that the work assumed anything like its present form.

The following States now have a system of Farmers' Institute work organized, and are under the control of a State Director, the State Board of Agriculture, or an Agricultural College or Experiment Station officer: Alabama, California, Delaware, Georgia, Idaho, Indiana, Iowa, Kansas, Maine, Maryland, Michigan, Minnesota, Mississippi, Missouri, Montana, New Hampshire, New Jersey, New York, North Carolina, Ohio, Oregon, Pennsylvania, Rhode Island, South Carolina, Vermont, Virginia, West Virginia and Wisconsin.

The Farmers' Institute is the result of the demand of modern agriculture for accurate information in regard to the underlying principles which control in the production of agricultural products. This demand for definite and exact knowledge in agriculture, did not become pressing so long as the lands were new and original fertility was abundant and available for the production of crops. It was not until the soil of the Eastern and Southern States had begun to be exhausted and crops to fail, that thoughtful citizens began to cast about for some means by which these lands could be restored, and their subsequent deterioration be prevented, and continuous and profitable crops be raised without permanent injury to the land.

In the effort to meet this question, which had become serious, the Congress of the United States in 1861, provided for the establishment of Colleges, whose leading object should be "to teach such branches of learning as are related to agriculture and the mechanic arts." Upon the establishment of these Colleges, it was some

years before those responsible for their control, were able to formulate a course of study which would meet the requirements of the country, or were able to secure the kind of teachers, competent to impart the information needed. After these requirements had been, in a measure, met by these new institutions, it was discovered that comparatively few of the young men of the country were willing to pursue the course of study, in agriculture, which had been prescribed. Whilst unquestionably, there was a pressing demand for information on agricultural matters, on the part of a large number of those who were actively engaged in farming, there was comparatively little demand for this knowledge, on the part of the young people in the schools. Instructors in these Colleges, also, soon discovered, that there was comparatively little reliable information to be had, in what is now known as "Agricultural Science," or the sciences in their relation to agriculture.

Out of these conditions, and to supply the needs for more extensive and accurate information, the Congress passed, what is known as the Hatch Experiment Station Act, which provided for the erection and support of Agricultural Experiment Stations in the several States, for scientific research and experimentation in agriculture. Since their establishment, and through the work of these Stations, the stock of agricultural knowledge has been greatly enlarged, and, is being daily, rapidly increased. This knowledge, if disseminated, will be to the great advantage of the agricultural interests of the country.

The problem that now requires solution, is that of getting this information which is in existence, and such other, as it is discovered, before the agricultural people of the country. Bulletins containing this information are being issued by the Stations, and by the Department of Agriculture, at Washington, but the large majority of the farming people are not reached by this method. This is notably true as regards the less progressive farmers, and the women and youth in the farmers' families.

THE INSTITUTE A DISSEMINATOR OF INFORMATION.

The Farmers' Institute has been organized to supplement the Agricultural College and the Experiment Station, in the work of disseminating information on agricultural subjects throughout the land. Its function is to take up-to-date, reliable and valuable truth, as it relates to agriculture; to carry it out to assemblages of people of both sexes and of all ages, and present it before them orally, in condensed and attractive form, and in shape to be applied in their every-day life; affording, at the same time, opportunity to all, who are interested, to ask questions on points that they do not fully understand.

The Farmers' Institute occupies the position, in the system of agricultural education of to-day, in this country, of that of a disseminator of agricultural knowledge among the masses, and of a stimulator of desire and respect for such knowledge, by the masses. The institute is not simply to reach those who are now actively engaged in the business of farming, but to reach, as well, the great masses of our population, who have little or no knowledge or appreciation of the advantages of agriculture, as a calling in life.

Its work is not limited to efforts to improve the condition of existing farmers, but contemplates as well the creating of new, as well as better farmers. It is wide extended in its influence, and ought to be of the highest grade. It should accordingly be planned and conducted upon lines correspondingly liberal, and commensurate with the dignity of the Department, and the field of usefulness that it is organized to fill.

THE INSTITUTE LECTURER.

Inasmuch as the work to be performed requires the service of experts, no one should be employed who is not thoroughly competent for the special service that he is expected to render. It should not be an asylum for lazy persons or incompetents, and no political considerations should enter into the qualifications of any one employed, and the compensation should be sufficient to induce the best experts in the country to desire the positions. Sufficient money should be appropriated to enable the Department to retain in its employ some of the most capable men during the entire year. The permanent employment of at least a few capable men and women should be the rule. Men who are competent, are, as a general thing, not unemployed, and their services cannot be had and dispensed with at pleasure. The institute lecturer or teacher is the heart of the institute work. If competent men cannot be had, then the whole system will be a failure, and the money that is expended be thrown away.

The development and training of these lecturers, should, therefore, be part of the work of the Department. They should be brought together several times each year for conference and study. They should be sent to examine and study the work of the State College, so far as it relates to agricultural affairs, and of the State Experiment Station. They should be put in the way of getting the best literature upon their several specialties. In short, they should themselves be students of agriculture, and be posted in all that takes place in their special work throughout the world.

THE DIRECTING OF THE WORK.

The directing of the Farmers' Institute work in Pennsylvania, is made the special duty of the Deputy Secretary of Agriculture. During the past season, there were scheduled and held 135 two day. and 54 one-day institutes, a total of 324 days, divided into 782 sessions. The Department sent out, at its expense, 51 lecturers to give instruction, and the local managers supplied 684 more, making a total of 735. These lecturers addressed in all, over 144,000 people (144,431). The average daily attendance was 445; the largest daily attendance for any one county was 925, and the smallest was 50.

For institute purposes, the State is divided into five sections, apportioning the work of each section as nearly equal as possible. The institutes began December 3d and continued to March 4th. At each institute the Department had present at least three of its lecturers, one of whom is the special representative of the Department, and has charge of the section. The local manager makes up the programme of exercises subject to the approval of the Director of Institutes.

The apportionment of time to be given to each county for institute work, is made on the basis of two days of institute to every county having not over 1,000 farms; three days to each county having more than 1,000 and not over 1,500; afterwards one day for each 1,500 farms or fraction thereof additional. This insures Department aid to each county in proportion to its agricultural interests. The following schedule shows the number of days allotted to each county and arranged upon this basis, for the season of 1901-1902:

APPORTIONMENT FOR 1901-1902.

Section 1.		Section 2.		Section 3.		Section 4.		Section 5.	
COUNTY.	Days.	COUNTY.	Days.	COUNTY.	Days.	COUNTY.	Days.	COUNTY.	Days.
Adams,	5	Blair,	4	Allegheny,	6	Bradford,	8	Bucks,	7
Bedford,	5	Columbia,	5	Armstrong,	5	Clarion,	6	Berks,	7
Chester,	7	Centre,	4	Beaver,	6	Cameron,	3	Carbon,	2
Cumberland,	4.	Clearfield,	4	Butler,	4	Elk,	3	Lehigh,	5
Delaware,	4	Clinton,	3	Crawford,	8	Erie,	6	Luzerne,	4
Franklin,	5	Cambria,	4	Fayette,	5	Forest,	3	Lackawanna,	4
Fulton,	3	Dauphin,	4	Greene,	4	Jefferson,	4	Montgomery,	6
Juniata,	4	Huntingdon,	4	Lawrence,	4	Lycoming,	5	Monroe,	4
Lancaster,	9	Indiana,	6	Mercer,	6	McKean,	4	Northampton,	5
Perry,	4	Lebanon,	4	Venango,	4	Potter,	4	Philadelphia,	3
Somerset,	5	Mifflin,	3	Washington,	5	Sullivan,	2	Pike,	2
York,	8	Montour,	2	Westmoreland,	5	Tioga,	6	Susquehanna,	6
		Northumberland,	4			Warren,	4	Wayne,	6
		Schuylkill,	4			Wyoming,	4		
		Snyder,	4						
		Union,	3						
	63		62		62		62		61

Past experience in most of the counties has shown that the two days institute is much more economical and efficient than the one-day meeting. In the one-day meeting the time is usually given to the visiting lecturers to the exclusion of local aid, on the ground that the people wish to hear the strangers, and as there is not time to hear all, the visitors are given the preference. This is a serious mistake. The main object of the institute is the development of the local people, and whatever interferes with this, ought to be corrected. A two day institute gives ample time for all to be heard, and provides, also for the deliberate and full discussion of matters of interest that may arise. The morning session of the first day is almost always a failure and ought to be dropped, and the institute begin at one P. M., and continue for five sessions. This gives time for the visiting lecturers to reach the ground, and begin the work with the advantage of a full house.

The demand for institutes is such, that it has now become very difficult to determine the localities which shall be favored. I wish to reiterate what I have said in reporting upon this work in previous years, that there should be appropriated for institutes at least $25,000 per year. The progress of the work has reached such a stage that this larger sum can be expended to the great advantage of our farming industry, and there will be returned to the State many-fold, that which it invests, in the furtherance of this great school of agricultural education.

DAIRY AND FOOD DIVISION.

The work of this Division is most important and extensive. The protecting of the people against food adulteration, and food substances injurious to health is worthy of the best efforts of the State. This work has been committed to the Department of Agriculture and the Legislature has enacted laws and appropriated money to secure this result. What has been done has been set forth in detail and published in bulletins and distributed for the information of the public. Before the publication of these bulletins, there was considerable criticism of the Department for supposed inactivity in the enforcement of the pure food laws, but the facts, as disclosed by the bulletins, effectually silenced all of these critics, by showing them the amount of work that has been done in this direction.

There was occasion, recently, to compile the work of the Dairy and Food Division for the two and a half years ending July 1st, 1902, which may be of interest to present in this report as showing the activity of the Department, and the effective character of its work. The following table gives a summary of what has been accomplished in the period named:

Samples of butter analyzed Jan. 1st, 1900, to July 1st, 1902,		3,023
Found to be pure,	1,019	
Found to be oleomargarine,	1,840	
Found to be renovated butter,	164	

All of these samples were sold as butter except 103, which were sold as oleomargarine, and 61 which were sold as butterine.

Samples of cheese analyzed,		31
Found to be standard,	15	
Found to be below standard,	16	
Samples of milk analyzed,		436
Found to be pure,	320	
Found to be adulterated,	116	
Samples of condensed milk analyzed,		29
Found to be pure,	21	
Found to be adulterated,	8	
Samples of vinegar analyzed,		135
Found to be pure,	76	
Found to be adulterated,	59	

The samples just mentioned, were taken under the provisions of special laws, passed for the regulation of the sale of these particular articles of food.

The following samples were taken under a general law, enacted in 1895, known as the Pure Food Law, the main features of which appear in its first three sections, which are as follows:

"Section 1. Be it enacted, &c., That no person shall, within this State, manufacture for sale, offer for sale or sell any article of food which is adulterated within the meaning of this act.

"Section 2. The term "food," as used herein, shall include all articles used for food or drink by man, whether simple, mixed or compound.

"Section 3. An article shall be deemed to be adulterated within the meaning of this act,

(a) In the case of food: (1) If any substance or substances have been mixed with it so as to lower or depreciate or injuriously affect its quality, strength or purity. (2) If any inferior or cheaper substance or substances have been substituted wholly or in part for it. (3) If any valuable or necessary constituent or ingredient has been wholly or in part abstracted from it. (4) If it is an imitation of or is sold under the name of another article. (5) If it consists wholly or in part of a diseased, decomposed, putrid, infected, tainted or rotten animal or vegetable substance or article, whether manufactured or not—or in case of milk, if it is the product of a diseased animal. (6) If it is colored, coated, polished or powdered, whereby damage or inferiority is concealed, or if by any means it is made to appear better or of greater value than it really is. (7) If it contains any added substance or ingredient which is poisonous or injurious to health: Provided, That the provisions of this act shall not apply to mixtures or compounds recognized as ordinary articles or ingredients of articles of food, if each and every package sold or offered for sale be distinctly labeled as mixtures or compounds, and are not injurious to health."

Under this act, one thousand three hundred and sixty-nine (1,369) samples of food were taken by the Department and analyzed:

	Total.	Pure.	Adulterated.
Table drinks analyzed,	141	60	81
Soda fountain drinks,	62	31	31
Meats, sausages, etc.,	259	158	101
Prepared foods,	33	22	11
Canned fruits and vegetables,	44	13	31
Syrups, sugars, etc.,	92	36	56
Table oils,	8	4	4
Baking powders,	70	44	26
Candies,	10	8	2
Spices and condiments,	271	98	173
Extracts,	296	53	243
Jams, jellies and marmalades,	39	15	24
Dried fruit,	1	1	....
Total,	1,326	543	783
Samples analyzed for special purposes,	43		
Total,	1,369		

This exhibit reveals not only the condition of the food products found upon the markets of the State during the two and a half years preceding July, 1902, but also shows the vast amount of work that has been performed in the interest of the public health. This work consisted not only in the collecting of the five thousand and twenty-

three samples of food products, often taken under quite difficult conditions, but also in the expert knowledge of a high character and in the painstaking labor, which were necessary, in order to analyze all of these samples, and to do this, in each case, with such accuracy and certainty as to warrant the analyst in testifying under oath, as to the correctness of his results.

Along with this was the work of the attorneys and agents in the prosecution in court of over two thousand cases which were brought, the collection of the fines and penalties ,the keeping of full and correct records in the office, and in the publication of the results, all of which ,it is believed, represents more work than has been performed in the same time, by the Food Departments of any three other States in the Union.

The Commissioner reports that during the past year, there had been collected by the agents, analyzed by the chemists, and reported to him, two thousand and fifty-two (2,052) samples of the several food products, and that of this number, 1,122 samples were found to be pure or true to name and 903 adulterated.

There were 310 licenses issued for the sale of oleomargarine, which brought into the Treasury of the State $23,927.05. Two licenses were issued for the sale of renovated butter, for which there was received and paid into the State Treasury $766.07. There were collected in fines and penalties and paid into the State Treasury the following amounts under the respective Acts:

FINES AND COSTS.

Pure Food Act,	$8,022 20
Oleomargarine Act,	8,463 93
Renovated Butter Act,	578 58
Milk Act,	1,177 24
Cheese Act,	169 50
Vinegar Act,	447 42
Lard Act,	23 00
Total,	$18,881 87

The total, therefore, collected during the year 1902 and paid into the State Treasury up to December 1st, was:

Oleomargarine licenses,	$23,927 05
Renovated butter licenses,	766 07
Fines and costs,	18,881 87
Total,	$43,574 99

These facts show that there are still unscrupulous compounders of foods, who are willing for personal profit, to drug with poison, and to dilute with inferior articles, the various foods which they offer to the consuming public; and whilst, as has been shown, much has been done in the past several years to clear the shelves, shops and markets of this State of adulterated and dangerous foods, there is necessity for continued activity, in order to secure universal compliance with our laws.

The responsibility for food adulteration can be fixed upon three distinct classes of people; the manufacturer, the jobber and the retailer.

The control of food adulteration as it affects the manufacturer, jobber and retail dealer, must, of necessity, be through the medium of laws regulating their trade, enforced by public officers delegated for the purpose. The proper framing of these laws, so as to protect the public against fraud and injury to health, is a task of no small magnitude. Care must be exercised, not to unnecessarily restrict, or injure, manufacturers and others, in their efforts to improve their processes, or in endeavoring to provide new combinations of food which are beneficial to the public.

These laws should be, both State and National. The State laws, to secure the proper control of foods produced and sold within the State; and the National laws, for the regulating of the character of foods on the markets outside of the State in which they were manufactured or produced.

All of these laws should be definite and explicit in their requirements, leaving as little as possible for interpretation or ruling by the executive, or for contention in the courts. The Pennsylvania Department of Agriculture has, with great care, and after frequent consultations with its corps of food experts, chemists, attorneys and agents, prepared and published a set of rulings, together with definitions and standards on food products, which it is believed will protect the public, are fair and just to the manufacturers and dealers, and are in strict accordance with the spirit of the law, regulating the manufacture and sale of food in this State.

Legislation, for the control of food adulteration, has thus far been confined to the several States, acting independently of each other.

As a consequence, these laws differ widely in their requirements and are embarrassing to manufacturers and jobbers whose foods go into all sections of the country. Those who are in charge of the enforcement of the pure food laws in the several states, are unanimous in the conviction, that a National Pure Food law is a necessity, if freedom from adulteration in food is ever to be a reality. State laws are, necessarily, confined in their scope, to State boundaries, and manufacturers and jobbers living outside of these lines, cannot be reached. All that can be done, is to arrest the dealer in the State, who handles their goods, and who, not infrequently, is innocent of any intention to deceive or cause injury to the public health.

In a paper recently presented by me before the National Association of Dairy and Food Commissioners, on this subject, I stated that a National food law should have six purposes, clearly defined:

"1st. It should protect the public health.

"2d. It should prevent fraud.

"3d. Such a law should protect foreign commerce.

"4th. It should provide for the proper labeling of all food products placed upon the markets.

"5th. It should provide for the fixing of standards.

"6th. The law should provide for the publication of the results of the work of the Bureau."

Such a law has been prepared, and has the endorsement of the National Association of Dairy and Food Commissioners, and will be presented before Congress at its next meeting. It should have the active support of all who are interested in securing pure food for the people.

SUPREME COURT DECISION.

A most important decision has been handed down by the Supreme Court of Pennsylvania affecting the question of the amount of a substance, which is in itself poisonous, that can be added to a food under the Pure Food Law of the State. The case is known as that of the Commonwealth vs. John W. Kevin, appealed from the Superior Court of Pennsylvania to the Supreme Court of the State. The opinion was filed by Judge Mestrezat, March 3, 1902. The case is stated as follows:

The defendant, who is engaged in the grocery business in the city of Philadelphia, was tried and convicted in the court of quarter sessions of Philadelphia county on an indictment charging him with having sold "one pint of raspberry syrup, the said raspberry syrup then and there containing an added substance and ingredient, to wit, salicylic acid, which is poisonous and injurious to health." The indictment was found under the act of June 26, 1895, P. L. 317, entitled "An act to provide against the adulteration of food and providing for the enforcement thereof," and commonly known as the Pure Food Law.

The first section prohibits the manufacture or sale of adulterated food, the second section defines the term "food" as used in the act, and the third section provides *inter alia* that "an article shall be deemed to be adulterated within the meaning of this act: (a) in case of food * * * (7) if it contains any added substance or ingredient which is poisonous or injurious to health." The defendant was indicted for a violation of the seventh clause of the third section of the act.

The court below held that "If the foreign substance added to an article of food is poisonous or injurious in any quantity, the statute declares it to be an adulteration." This position was affirmed by the Supreme Court in the following language:

"We are of the opinion that the learned trial judge properly interpreted the act of Assembly under which this indictment was drawn, and that, therefore, his rulings on the admission of testimony, and his answer to points for charge, which are complained of in the assignment of error, were correct."

This decision has greatly simplified the work of the Department in enforcing the Pennsylvania Food Laws. There can now be no defense set up, that the quantity of the poisonous substance is so small as to have no injurious effect upon health, but if it can be shown that any added poisonous ingredient is present in even the smallest quantity, the defendant is liable to the penalty prescribed by the law.

ACTION OF STATE MEDICAL SOCIETY.

Early in this year an invitation was received by the secretary of the Department to appear before the Medical Society of the State of Pennsylvania, at their annual meeting to be held in Allentown, Pa., September 16th, 17th and 18th, to address them upon the subject of "Food Adulteration." In presenting the subject, the fact was brought out that there is lack of agreement in the medical profession, in regard to the effect upon health of certain preservatives frequently found in foods. Inasmuch as this lack of unanimity of opinion has been a serious embarrassment to the Department in its enforcement of the laws, I take the liberty of quoting from that address the portion which relates to this subject:

"I can bear testimony to the valuable service, which members of this association have rendered the food authoratives of this State, when called upon to testify as to the effect of certain specified adulterations, upon the health of the persons who consume them. At the same time, I call your attention to the fact, that those who are on trial for adulterating foods, or selling foods that have been adulterated, confront us with medical experts who testify, that salicylic

acid is not injurious to health, and that boracic acid compounds and benzoate of soda are harmless ingredients of food. Thus doctors disagree. Has medicine still to depend upon opinions, or guessing, in matters such as these? Why should medical testimony, on subjects so important conflict among men who have graduated from the same school of medicine, and have had equal opportunities to observe? Pure food officers, judges and juries are dependent upon you, for testimony as to the effects of ingredients found in food, upon the public health. We can go no further than you permit. A bill was before the last Legislature to protect meat from adulteration by the use of salicylic acid, and it failed, because eminent physicians declared, before the committee of the Senate, that they used it in their practice with no harmful effects upon the public health. The Department recently lost an important case in which borax had been used, through the evidence of local physicians who did not think it harmful as a preservative of butter.

"Would it not be well for this Society, to appoint a committee of its most experienced members, to take up the question of the effects of the various substances now employed for the preservation and adulteration of our foods, and report their conclusions to this body at its meeting in 1903? The field of food adulteration is a wide one, and needs investigation more, perhaps, than any other. The duty, sooner or later, must fall upon you, and I urge that you do not defer, but take it up at once, and aid in settling, once for all, all doubt as to the character of these substances, that are now so freely and indiscriminately used, to dose our foods.

"The officers who enforce the food laws in this State must face the difficult questions which continually arise in the matter of the coloring and preserving of foods as well as the right of manufacturers to lower or depreciate their value, through the addition of cheaper substances of inferior grade. Many of these questions are pathological in their character, and require for their proper answer, knowledge which only experts and specialists can supply. If a properly qualified board, made up of members of your society, were appointed, these questions could be referred to them, and their reply would often determine the action which should be taken."

In response to this request the Society passed the following resolution:

"*Whereas*, The Department of Agriculture of the State of Pennsylvania through its work in the examination of food, discloses the fact, that there are in the general market, foods that either are below the standard of commercial value, or those that are adulterated by the mixture of poisonous or injurious matters, either to increase the profit, change the color and texture, or to unduly preserve from

decomposition, and as these changes have in many instances been followed by the arrest and conviction of the manufacturers or dealers, in the different courts of our State, proving that the claims of the Department of Agriculture are well grounded, and their efforts to protect the health of the people demands our co-operation.

"*Resolved*, That the President of the Medical Society of the State of Pennsylvania, appoint a committee of five members, who shall consider the question of food adulteration, the use and abuse of the various so-called preservatives and the coloring of food, and the effect of these adulterants upon the health of the people. This committee, if appointed, to investigate and report at our next annual meeting; and be it further

"*Resolved*, That the officers of the Department of Agriculture of the State of Pennsylvania be asked to co-operate in the work of our committee."

The committee was duly appointed with Dr. Henry Leffman, of Philadelphia, as chairman.

This action by the Medical Society, representing a membership of over 3,500 physicians will, unquestionably, result in great good to the general public, and materially assist the Department in its enforcement of the Pennsylvania food laws.

A DIVISION OF ANIMAL HUSBANDRY.

It is apparent, from the amount of work which the Dairy and Food Division has performed in the enforcement of the food laws of the Commonwealth, that there is no time for giving proper attention to that other branch of the work of this Division, namely, the development of our dairy industry.

We do not at present supply much more than one-half of the butter needed by our citizens. With the facilities for milk production which this State affords, we should not be dependent upon our neighbors for our supply of dairy products. Special attention to this branch of our farming industry, by a capable and enthusiastic officer, unembarrassed by the difficulties attending food control would soon bring about an increase in our dairy production.

We have also the question of an increase in our home raised beef supply. Many thousands of acres of land throughout the State are admirably adapted to the growth of beef and mutton. The great ranges of the West have almost disappeared, and the supply of the future must soon be grown upon the smaller farms of the East, South and middle West. There are also the breeding of swine and poultry which have never yet been seriously taken up in Pennsylvania. Hitherto they have rather been adjuncts or subordinate

branches of our farm production. No more profitable branch of farming exists than this, if properly understood and conducted. There is also an increasing demand for well bred horses for draft and driving purposes. A large part of the supply for use in Pennsylvania is brought from other States which are no better situated than our own for the breeding of this class of our domestic animals.

These subjects, representing as I have elsewhere indicated, an investment of about $125,000,000.00, could easily be increased to double or treble their present number.

The State Live Stock Sanitary Board already has its special work in caring for the health of our live stock, and conducting investigations into the causes of, and discovering remedies for, the diseases that affect domestic animals throughout the State.

The particular work, therefore, now needed, and for which no provision has been made, is the looking after the commercial side of the live stock industry of the State. I suggest that a Division be created in the Department of Agriculture, to be known as the Division of Animal Husbandry, to be under the direction of a Commissioner who shall have a clerk, and be charged with the work of assisting and building up the live stock industry of the State.

Such a Division would cost the State the salary of the Commissioner, $2,500.00, and that of his clerk, $1,500.00, a total of $4,000.00, a small sum to expend, in promoting the interest of this most profitable and important branch of our farming industry.

DIVISION OF ECONOMIC ZOOLOGY.

The work of this Division during the year has been largely confined to the receiving and tabulating of the reports of the nursery inspectors, and the issuing of certificates to nurserymen, declaring that the nursery has been inspected and found to be free from San José Scale, and other dangerous insect pest or pests.

The presence of San José Scale in many orchards in the State has made the work of the nurseryman most difficult. He is expected to keep his nursery free from this pest, although his neighbors have it in their orchards, from whence it is carried by birds into the grounds of the nurseryman, and infests his stock. It is, therefore, becoming practically impossible for our nurserymen to keep their stock clear from infestation. Pennsylvania is not exceptional in this respect, for the same difficulty is encountered in almost all of the other States.

When the San José Scale first appeared, entomologists set to work to stamp it out, and adopted the most heroic treatment for this purpose. There was general destruction of infested trees ordered on every hand, and yet the scale spread more rapidly than the destroyers could follow it, until it became evident, that the continuance of this treatment would ultimately result in the loss of all the fruit orchards of the country. Orchard and nursery inspectors were consequently compelled to abandon this method as a remedy, except in extreme cases, and devote their attention to the discovering of some insecticide that would be destructive of the insect, and yet do no injury to the plants to which it is applied. In short, they endeavored to find a means of controlling the spread of this insect, rather than to attempt the destruction of every single scale.

This has resulted, after much careful study and experimentation, in their recommending three preparations, any one of which has been found reasonably effective for this purpose. Crude petroleum either mixed with from 75 to 80 per cent. of water, or used pure; whale oil soap; and lime salt and sulphur, or sulphate of copper wash. The latter two preparations are free from danger of doing damage to the trees, and whilst the first is attended at times with injurious effects, it is, perhaps, the most efficient in destroying the scale.

The Department has had several experts prepare bulletins of information upon the use of these and other insecticides. One by Dr. H. T. Fernald, Entomologist for the State of Massachusetts, one by Dr. J. B. Smith, Entomologist for the State of New Jersey, one by Dr. A. V. Stubenrauch, Instructor in Horticulture in the University of Illinois, and one by Prof. H. A. Surface, Professor of Zoology in The Pennsylvania State College. The dissemination of this information among our orchardists and nurserymen will be of great value in enabling them to combat these insect foes.

At a general meeting of the nursery inspectors of the several States, and of the entomologists connected with the colleges and Experiment Stations of this country at Atlanta, Ga., in October of last year, at which this Department was represented, the following resolutions relating to nursery inspection were adopted.

1st.—"Resolved, That the examining or certifying officer of each State, accept at its face value the statement made in certificates duly granted under the laws of their State, so far as the laws of his own State admit, unless information at hand creates reasonable doubt as to the regularity of the certificate or its application.

2d.—"That the inspectors of the several States should freely and frankly exchange communications with regard to nursery infestation and attempts at evasion of the laws, as might, from time to time, come to their notice.

3d.—"That inter-state co-operation for the control of horticultural pests whose area of destruction extends across State lines, is most desirable, and should be as complete as the laws of the States concerned will permit, and that in the treatment of any particular pest, preference should be given to such cases.

4th.—"That it is the sense of this body that the nurserymen should not be required to pay the expense of the ordinary inspection of nursery stock.

5th.—"That the entire cost of insecticide or fungicide measures required by law, should be borne by the owner of the affected property.

6th.—"That in the opinion of this meeting, nursery stock fumigated according to accepted requirements, should be considered as satisfactory as stock sold under certificates of inspection only."

The last resolution was adopted with the understanding that fumigation is not to supplant, but rather to supplement inspection. The resolutions are quoted in full and show how far the best scientific experts have gone in the matter of nursery inspection, and in the treatment by fumigation, of nursery stock.

The action quoted, taken in connection with the report of the committee appointed to consider the question of the best insecticides to use for the destruction of San José Scale in orchards and nuseries in this country, made at the meeting in Washington in November, 1901, makes clear the position of the leading authorities on the subject of the control of San José Scale. The report of the committee is as follows:

"The committee after due consideration finds itself able to agree upon the following recommendations for treatment:

1st.—"For Nurseries: Proper fumigation with hydrocyanic acid gas after inspection.

2d.—"For Orchards: Late summer and fall treatment with dilute solutions of insecticide soaps, oils or other effective insecticides to kill young scales. Winter treatment, with insecticide soaps or oils sufficiently strong to kill the scale, which have been proved safe to trees of all kinds in the region where the application is to be made."

NURSERIES IN PENNSYLVANIA.

Pennsylvania is deeply interested in this subject, for we have 145 nurseries, with a total acreage of 2,720½ acres. Of this acreage our inspectors report, as being in very good condition, 1,738½ acres; in good condition, 505 acres; in fair condition, 224½ acres; and in poor condition, 252½ acres. There were 135 certificates granted, and 10 refused.

The inspectors of the Department are instructed to examine the following plants for San José Scale, inasmuch as all of these are susceptible to its attacks, namely: Grapes, Lindens, Euonymus, Almond, Apricot, Apple, Cherry, Cotoneaster, Hawthorns, Peach, Plum, Pear, Quince, Raspberry, Rose, Spiraea, Gooseberry, Currants, Persimmons, Acacia, Lilacs, Privet, Elm, Osage Orange, English Walnut, Pecan, Alder, Willows.

CONTROL OF INSECT PESTS.

The work of controlling insect pests in orchards and nurseries, is only dealing with insects as they affect a single branch of agriculture, whereas the depredations of insects and the destruction occasioned by fungus diseases, extend to all crops, and to every plant in every crop. They are to-day the most threatening and formidable of the enemies which the agriculturist has to meet. They multiply by myriads, and unless controlled will cause the destruction of much useful vegetable life.

The combating of these hosts is a work of great magnitude and difficulty, and its importance cannot be exaggerated. It requires experts of the greatest experience and most accurate knowledge, to even attempt to overcome the difficulties that must be encountered and discover remedies which are effective, and which the ordinary farmer can safely apply. The loss to the United States, annually, from injurious insects, is given at about $300,000,000; or about one-tenth of our agricultural production, is lost through the depredations of insects.

HESSIAN FLY INVESTIGATION.

This Department, over a year ago, engaged the services of Prof. H. A. Surface, Professor of Zoology in The Pennsylvania State College, to make an investigation as to the ravages of the Hessian Fly, with a view of discovering a method of treatment, by which our wheat crop may be protected against it. This investigation has been concluded, and the report is now ready for the printer. Many thousands of samples of wheat were collected from all parts of the State, at regular intervals of time, and examined for the presence of the fly. The report shows that wheat plants, taken from fields sown in August were all infested, and that the number of the infested plants from fields sown later, diminished until the last of September, after which no fly was found. The report is of great value, and ought to be distributed by the thousands over the State.

As an example of the service which the Department is rendering in the way of giving information in regard to the treatment of crops for protection against insect pests, the following may be taken as an illustration. A prominent grower of canteloupes in this State lost his crop in 1900 from an attack of plant lice. On the 15th of

August, 1902, he came to the Department greatly excited, because of the appearance of this same enemy in his field this year, which threatened the destruction of his crop. The Department immediately notified a prominent entomologist in the State, and requested him to visit this farm, and do what he could to arrest the destruction. His visit saved the crop, which meant to the farmer escape from serious financial loss. There is scarcely a limit to the usefulness of this Division in assisting agricultural people with advice, and by personal visit, by experts who have been thoroughly educated in the science of entomology.

A DIVISION OF HORTICULTURE AND POMOLOGY.

In the absence of any other suitable place in the Department, there was assigned to the care and attention of the Division of Economic Zoology the important branch of our agriculture, embraced by the term Horticulture. The climate, soil and situation of Pennsylvania all combine to make it one of the most desirable States in the Union for fruit farming. No other State produces fruit of finer flavor or of more attractive appearance. Apples, peaches, pears, plums, grapes and small fruits can be grown anywhere in our State with fair success, but if localities are selected, which the State affords, that are specially adapted to the growth of each of these several fruits and their varieties, then we surpass other States, in the abundance, quality and appearance of our product. The Department recognizing the importance in fruit growing, of discovering the kind of soil, elevation, slope, degree of moisture, distance of the water level from the surface, and the climatic conditions, adapted to the producing, in perfection, of the several varieties of fruits, started an investigation about one year ago, the results of which have been published in Bulletin No. 106, to discover the places in our State where each variety of fruit has shown the best results. The bulletin giving this information, it is believed, will be of great assistance in locating orchards, and in selecting the particular varieties of fruit which are adapted to given localities.

The subject of Horticulture has been so important in our State, that it ought no longer be relegated to a subordinate position in a Division of the Department, to which it is not naturally related. There should be established in the Department of Agriculture a Division of Horticulture, with a Commissioner of Horticulture as its chief, and a clerk as an assistant, so that this great interest may have the help of the State in its development, and be under the continual care of an officer who is an expert in this respect. I therefore repeat my recommendation of two years ago, that a Division of Horticulture and Pomology be established in this Department, to be equipped with a commissioner and clerk, and provided with proper facilities for carrying on its work.

DIVISION OF VETERINARY SCIENCE.

The office of the State Veterinarian has experienced a year of unusual activity and progress. As heretofore, the greater part of the State Veterinarian's work has consisted in aiding herd owners who wish to eradicate tuberculosis from their herds and, with this object in view, enter voluntarily into a contract with this Commonwealth under which they receive important assistance, on condition that they will do what they can to make the work permanent. Other diseases of animals, have also required much attention during the year. "Rinderseuche" have been the most important, because the most prevalent. There has been less anthrax and black-quarter than for several years, and due, it is believed, to the systematic vaccination against these diseases that has been practiced on rather a large scale during the past few years.

Ever since the organization of the work of the State Live Stock Sanitary Board, a laboratory has been maintained for the production of the tuberculin, mallein and anthrax vaccine used in the regular work of the Board. The cost of maintaining the laboratory, has been more than made up, in the value of these products. But in addition to this work, the laboratory has served a most useful purpose in affording facilities for the diagnosis of specimens from diseased animals, and has by this service considerably increased the efficiency of the veterinary profession of the State. Outside of all of this routine work, the laboratory has furnished the opportunity for conducting a rather remarkable volume of research. This division of the work has been most fruitful, and has been the means of revealing many new and serviceable facts in connection with the pathology, the diagnosis, and the prevention of some of our most prevalent and destructive animal diseases. The most notable achievements in this line during the past year have been, first, the establishing of the essential identity of the animal and human tuberculosis; second, the development of a method for immunizing cattle against tuberculosis by vaccination, and, third, the indentification of the "Rinderseuche" as the disease that has heretofore been called the "mountain disease of cattle" and has caused considerable losses in some of the rougher parts of the State.

In regard to tuberculosis, the number of inspections is limited only by the funds available for making them. There are several

times as many applications from herd owners as can be responded to under the existing financial limitations. Since all herds whose owners apply for an inspection and tuberculin test, can not be inspected and tested, and all tubercular cattle removed as is desired, the attempt is at all times made, to test the herds that appear to be most extensively infected, and in respect to other herds, to remove the animals that are most immediately dangerous. In this way 912 tubercular cattle have been considered and destroyed during the year. These were appraised at $26,306.25. There is at present a most active desire on the the part of cattle owners to free their herds from tuberculosis. They appear to keenly realize the harm the disease is doing, and are willing to co-operate with the State Veterinarian to repress it. Indeed, as stated above, they constantly apply, of their own volition, for more aid than the State Live Stock Sanitary Board can pay for. The result of this interest is, that tuberculosis of cattle is being repressed in Pennsylvania at a gratifying rate, and each year shows less loss from this cause.

There have been 35 cases of glanders in the State during the past year. Most of these diseased animals were involved in two outbreaks of the disease, one of which came from a glandered mule from East St. Louis, and the other was traced to a pony from Maryland. By immediately checking such outbreaks, the dissemination of the disease and the infection of the horse stock of the State, is prevented. The value of this protection is apparent, when it is known, that in Massachusetts with about one-fifth the area of Pennsylvania, there are from seven to eight hundred condemnations on account of glanders each year.

Rabies has prevailed rather extensively, and nearly all parts of the State have been involved. It is extremely difficult to prevent this disease, and it is scarcely possibly without establishing a general quarantine of all dogs in infected districts. In order that this may be done effectually additional legislation is necessary, and a bill covering this ground will be submitted to the incoming Legislature.

The discovery of "Rinderseuche" has cleared up a question as to the identity of a disease that has prevailed rather extensively among cattle turned out in some of the rougher mountainous parts of the State. This disease has been shown to exist in only two other parts of the United States, but now that attention has been called to it, it may be found that it is of much wider distribution than has been supposed.

All things considered, the most notable achievement of the year, so far as the work of the State Veterinarian is concerned, is the development of a means to vaccinate cattle for the prevention of tuberculosis. This process consists in introducing into the system of the

animal a culture of the tubercle bacillus, so attenuated, as to be incapable of producing disease. After a few treatments of this sort, the animal is able to resist, without sign of the least injury, inoculation with virulent tubercular material that is fatal for unprotected animals. This work has gone far enough to show that the principle upon which it is based is sound. It now remains to develop the methods that are necessary to make this system of general service. The State Veterinarian and his assistant, Dr. S. H. Gilliland, are now actively at work on this problem and are of the belief that they will soon be able to solve it. The immense practical value of this discovery cannot now be fully estimated. It is clear, however, that successful vaccination against tuberculosis of cattle will save the State annually far more than the entire cost of the work of the State Live Stock Sanitary Board, and of the entire Department of Agriculture. The State is to be congratulated upon the foresight of the Legislature, that led to the maintenance of the laboratory and research work of the State Live Stock Sanitary Board. It has already paid for itself many fold in laboratory products for use in diagnosticating and preventing disease, and in other actual results now to its credit.

COMMERCIAL FERTILIZERS.

The new law regulating the manufacture and sale of commercial fertilizers went into effect January 1, 1902. The act increases the license fee, on brands sold in amounts under one hundred tons, from ten to fifteen dollars, and enlarges the powers of the Secretary in enforcing the law.

The increased fee has added materially to the amount available for analytical work, and will, it is believed, enable the Department to have analyzed each year, a sample of every brand found upon the market.

There were sixty-five more brands licensed this year than last; there being one thousand and one licensed in 1901, and one thousand and sixty-six in 1902. The agents collected fourteen hundred and forty-one samples this year, of which 923 were analyzed.

The samples analyzed are classified as follows:

Complete fertilizers, containing phosphoric acid, potash and nitrogen,	572
Dissolved bone, containing phosphoric acid and nitrogen,	4
Rock and potash, containing phosphoric acid and potash,	108
Acidulated rock, containing phosphoric acid,	197
Ground bone, containing phosphoric acid and nitrogen,	55
Miscellaneous, containing potash salts, nitrate of soda, etc.,	7
Total samples analyzed in 1902,	923

Under the old act, the Secretary had no power either to compel payment of the license fee, or to prosecute a manufacturer or dealer whose goods fell below the guarantee marked upon the sacks. The present law corrects these defects, and greatly aids in securing prompt attention to correspondence and compliance with the requirements of the law.

The chemical determinations to which a complete fertilizer is subjected are: 1, moisture; 2, phosphoric acid—soluble, reverted and total; 3, potash soluble in water; 4, nitrogen; 5, chlorine, for the purpose of determining the proportion of potash as a muriate.

Ground bone is subjected to a mechanical analysis by means of sieves, dividing it into fine and coarse. The diameter of the mesh of sieve for fine bone being one-fiftieth of an inch, and that of the coarse above this dimension.

INSTRUCTIONS TO SAMPLING AGENTS.

Fertilizer manufacturers sometimes allege that there have been errors made on the part of our sampling agents in selecting samples for analysis. It is due these manufacturers, as well as this Department, that the greatest care shall be exercised on the part of all connected with this work, to insure that the samples are fairly taken, are properly sealed and labeled, and are sent to the chemist in exactly the condition in which the goods were found.

In order, therefore, that there may be uniformity of practice on the part of our agents, the following instructions have been prepared for their guidance, and strict adherence to these directions is required:

1st.—No sample shall be taken from the manufacturer's warehouse.

2d.—No agent shall draw more than two samples of any one brand of fertilizer, unless for some special reason, which he shall state in his report.

3d.—Two samples of each brand shall be taken, if possible, selecting them from different localities.

4th.—Each agent shall make report from time to time in duplicate, giving the number of each sample taken, in consecutive order; the name and the address of the manufacturer, the name and address of the agent selling the goods from which the sample is taken; an EXACT copy of the name of the brand of fertilizer; and the selling price per ton of 2,000 pounds, at point of selection. He shall then subscribe his name to each report and send one copy to the official chemist, and the other to the Secretary of Agriculture, at Harrisburg, Pa.

5th.—Agents shall occasionally weigh a bag of fertilizer, to verify the markings as to weight.

6th.—Agents shall keep full memoranda of all the samples; stating the number of packages from which the sample is taken, together with such additional notes of information as may be of service for future reference, in case the accuracy of their work is called in question.

7th.—The sample for analysis must be taken from at least four sacks. The sampling tube to run its full length from the top toward the bottom down the centre of the sack, then turned two or three times to fill it, and the contents emptied upon a sheet of clean, tough paper. The samples from the four sacks to be then thoroughly mixed together, rolling the fertilizer back and forth across the paper by lifting the sides alternately. After thoroughly mixing, take a spatula and run it close along the paper under the mixture, lifting it straight up so as to get a perfect cross section of the heap.

8th.—The sample taken as in paragraph 7, is to be AT ONCE packed into the glass bottle provided for the purpose; the lid immediately screwed down tight, and upon the label attached, give the name of the sampling agent and the number of the sample, as marked upon the agent's list. The bottle containing the fertilizer, to be at once inserted into the paper case provided, first writing his name and the number corresponding to that on the bottle on the outside of the case. Then moisten the gum flap and seal securely.

9th.—In shipping to the chemist, great care is to be taken to so pack the bottles as to avoid breaking, and the shipping directions should be securely attached to the package, with the name also of the sampling agent marked on the box.

10th.—Agents will keep the Secretary of Agriculture informed in advance of the points to be visited, so as to be promptly reached by telegraph or mail, if necessary.

VALUATIONS OF FERTILIZERS.

The market value of a commercial fertilizer is governed by the cost of the several ingredients which compose it, adding freight, cost of bagging, mixing and agents' commission. The value, therefore, is subject to the variations in the market price of nitrogen, phosphoric acid and potash in their various forms. Each year, therefore, the list of prices used by the Department for the computation of values, is revised and published for the benefit of purchasers. The schedule of values for fertilizer ingredients for 1902 is as folllows:

Schedule of Values for Fertilizer Ingredients, 1902.

	Cents per pound.
Nitrogen:	
In ammonia salts,	16½
In nitrates,	14
In meat, dried blood and mixed fertilizers,	16½
In cotton seed meal and castor-pomace,	16½
In fine ground bone and tankage,	11
In coarse bone and tankage,	9
Phosphoric acid:	
Soluble in water, in bone fertilizers,	5
Soluble in water, in rock fertilizers,	3
Soluble in ammonium citrate, in bone fertilizers,	4½
Soluble in ammonium citrate in rock fertilizers,	2½
Insoluble in ammonium citrate, in bone fertilizers,	2
Insoluble in ammonium citrate, in rock,	1½
In fine bone, tankage and fish,	3
In coarse bone and tankage,	2½
In cotton seed meal, castor pomace and wood ashes,	4
Potash:	
In high-grade sulfate or in forms free from muriate,	5
As muriate,	4½

Potash in excess of that equivalent to the chlorin present, will be valued as sulfate, and the remainder as muriate.

Nitrogen in mixed fertilizers will be valued as derived from the best sources of organic nitrogen, unless clear evidence to the contrary is obtained.

Phosphoric acid in mixed fertilizers is valued at bone phosphoric acid prices, unless clearly found to be derived from rock phosphate.

Bone is sifted into two grades of fineness: Fine, less than 1-50 inch in diameter; coarse, over 1-50 inch in diameter.

The result obtained by the use of this schedule does not cover the items of mixing, bagging, freight and agents' commission. To cover these, allowances are made as follows:

For freight, an allowance of $2.00 per ton on all fertilizers.

For bagging, an allowance of $1.00 per ton on all fertilizers, except when sold in original packages.

For mixing, an allowance of $1.00 per ton on complete fertilizers and rock-and-potash goods.

For agents' commission, an allowance of 20 per cent. is added to the cash values of the goods ready for shipment.

The mean quotation on freight from New York, Philadelphia and Baltimore to Harrisburg, in January, 1897, was $1.68 per ton, in lots of twelve tons or over; in May, 1899, quotations by the Pennsylvania Railroad were: From New York, $2.40; from Philadelphia, $1.70; and from Baltimore, $1.55; mean rate from the three points, $1.88.

PUBLICATION OF RESULTS OF ANALYSES.

The results of the analyses of samples collected, are published each year, in two bulletins, one containing the samples taken and analyzed in the spring, and the other those taken and analyzed in the fall.

These bulletins have been in great demand by farmers and dealers, and are being carefully studied by them with a view of securing fertilizers from manufacturers whose goods are up to their guarantees, and who offer the most advantageous rates. The growing practice among our farmers of studying the needs of the soils they cultivate, and the character of the fertilizers suited to these requirements, is one of the most hopeful indications of progress. They are rapidly coming to learn, that agriculture requires for its proper pursuit intelligent and careful management, that the soil will no longer bring abundant harvests without added nourishment, and that the securing of this in the cheapest and most available form is a problem that each one must, in a great measure, solve for himself. Science is disclosing the constitution of fertilizers, plants and soils. The question of the best adaptation of these to each other, must always be left to the individual who grows the crop. He must himself experiment and determine what his particular soil needs to grow a particular crop. To do this successfully requires that a man shall be a close observer and have trained powers of investigation and thought. These qualities are acquired through the reading of scientific discussions of the subjects, by becoming familiar with the results of the work of other experimenters in agriculture, and by studying the principles that underlie plant life and growth in their various forms. The winter months afford ample leisure to the average farmer to thoroughly post himself on what is known on the subject of fertility, and to take up, systematically, the subject of fertilizers, their action and proper and economical use.

SPECIAL INVESTIGATIONS.

A number of scientific experts have been at work for the Department during the year, in making special investigations into subjects relating to agriculture, upon which the public need accurate information. The ordinary farmer has not the time to give to such investigation, even if he had the scientific knowledge requisite to fit him for the work. Scientists who are devoting their lives to such investigation must, therefore, be employed, and it is difficult to secure their services owing to their being engaged in scientific institutions, where the multitude of regular duties that these men are expected to perform, fully occupy their time.

At best, the number of those who are competent for this work, is quite limited. Comparatively few have made thorough study of agricultural problems in their deeper mysteries, and, therefore, but few are able to speak with authority upon the subjects which vex the agriculturist and need immediate solution. What the Department secures, therefore, of this character of work, must be taken from the vacation days and recreation hours of these men.

During the past year the following subjects were under investigation, some of which were reported upon in bulletin form, and others are still incomplete.

Investigation, into the habits of the Hessian Fly, with the view of discovering when grains may be sown in the various localities in the State, to avoid its ravages. This investigation has now been under way since the spring of 1891.

Investigation, into the most economical methods for the production of beef in Pennsylvania.

Investigation, into the science of dairying.

Investigation, into the proper heating, lighting and care of greenhouses.

Investigation, into the best means for the control of insects injurious to cucurbitaceous plants.

Investigation, into the best methods for canning fruits and vegetables.

Investigation, into the character of canned goods found upon the markets.

Investigation, into the character of soil bacteria in their effects upon plant growth.

Investigation, into the growing of hot-house lambs for early market.

Investigation to discover the best methods of preparing and applying insecticides.

Investigation, for the determining of the best form of horse for special purposes.

Investigation, into the use of phosphates and their effects in growing crops.

Investigation, for determining the best methods of destroying San José Scale.

Investigation, for discovering the fruits adapted to the various soils and districts of Pennsylvania.

Investigation, into the characteristics of the potato, and the best methods for its cultivation.

Investigation, into the effects of various vegetable substances in the improvement of soils.

Investigation, of the system of agricultural fairs, with a view of suggesting methods for their improvement.

Investigation, into the effects of feeding steers for beef in open sheds.

Information is much needed upon all of these subjects, the data for some of which required years of careful observation and experiment to collect and properly digest. In some instances the results are the work of a lifetime of study and experimentation, all embodied perhaps in a few pages only, of printed matter, but of such vital importance to the farmer, as to be of inestimable value in enabling him to understand and properly apply scientific truth, that previously he had never understood.

The securing of the preparation of bulletins of information such as are here referred to, is a most important part of the work of the Department, in its efforts to enlighten and assist country people, in those things which most nearly affect their life and occupation.

PUBLICATIONS.

The Department has prepared and published during the year its Seventh Annual Report, in two volumes. Volume one contains 1,040 pages, and volume two 464 pages. The law provides for the printing of 31,600 copies of this report, to be distributed to the Senate 9,000 copies; to the House of Representatives 20,000 copies; to the Department of Agriculture 2,000 copies; to the State Librarian 500 copies; and to the State Agricultural Experiment Station 100 copies.

The Department is seriously embarrassed in not having a sufficient number of these reports to supply the demand. At least 5,000 copies should be given to the Secretary for distribution. Requests come from all of the States, and from foreign countries, for copies of our reports, many of which have to be denied owing to the supply having become exhausted.

The Department is endeavoring to improve the character of its Annual Reports each year, by excluding all superficial and irrelevant matter, and publishing only that which has been well digested and which promises to be helpful to agricultural people. The addition of an Appendix, containing statistical data, has supplied the farmers of the State with useful tables for reference, and has been highly commended.

The law authorizes the Secretary to print bulletins of information "upon such subjects relating to agriculture as he may deem useful." Each publication is limited to five thousand copies, a number altogether inadequate for the supply of the demand for some of the editions. The law should permit the Secretary, in his discretion, to print copies of any bulletin to a limit of 25,000, the number being governed by the demand for the publication. Bulletins for which there is likely to be slight demand would have the edition restricted to the number that would probably be needed, and if it was discovered later that the edition was inadequate, there could be a second and third edition published, up to the 25,000 limit.

The Department has published since its organization in 1895, one hundred and six of these bulletins, embracing a wide variety of subjects, treated by some of the most capable investigators in the country. During the past year there have been published nineteen bulletins, upon the following subjects:

No. 88. List of Creameries in Pennsylvania.

No. 89. Tabulated Analyses of Commercial Fertilizers.

No. 90. Treatment for San José Scale in Orchard and Nursery.

No. 91. Canning of Fruits and Vegetables.

No. 92. List of Licenses Granted by the Dairy and Food Commissioner.

No. 93. The Fundamentals of Spraying.

No. 94. Phosphates—Phosphatic or Phosphoric Acid Fertilizers.

No. 95. County and Local Agricultural Societies, 1902.

No. 96. Insects Injurious to Cucurbitaceous Plants.

No. 97. The Management of Greenhouses.

No. 98. Bacteria of the Soil in their Relation to Agriculture.

No. 99. Some Common Insect Pests of the Farmer.

No. 100. Containing Statement of Work of Dairy and Food Division from January 1, 1902, to June 30, 1902.

No. 101. Tabulated Analyses of Commercial Fertilizers.

No. 102. The Natural Improvement of Soils.

No. 103. List of Farmers' Institutes of Pennsylvania.

No. 104. Modern Dairy Science and Practice.

No. 105. Potato Culture.

No. 106. The Varieties of Fruit that can be Profitably Grown in Pennsylvania.

These nineteen bulletins, if bound together, would make a volume of 1,587 pages.

No Experiment Station in this country has done as much, and it is questionable if the National Department of Agriculture at Washington has done more, or better work in this respect.

LIBRARY.

A well selected Library of agricultural books, is an important part of a State Department of Agriculture. An office for the Attorney General of the State without a suitable law library, would be deficient in an essential part of its equipment, and yet it is no more necessary for the proper performance of his duties, than is a library of reference for the Secretary of Agriculture and his Division officers. They are continually called upon for information upon important scientific and practical questions, and ought to have at hand the latest and best authorities upon these subjects, to which to refer. The scope of the Department is so wide, and the questions that come so important, that no ordinary library of reference will be adequate for its use.

A large and carefully selected set of books should be, at once, secured for Department use. Such a library would also be valuable as a place of reference for citizens of the State, who wish to learn what is known upon a particular subject relating to agriculture, in which they are interested. Editors, teachers, essayists and practical farmers, all need access, at times, to such a library. A few thousand dollars invested in this way will be very well expended, and ought to be appropriated by the coming Legislature without further delay. All of the more progressive States have such libraries as part of their equipment, and the National Department of Agriculture at Washington has one of the largest and best in the country. Pennsylvania should not be behind her sister States in this respect, but should at once take measures to supply this need.

MUSEUM.

The need for a Museum, representing the agriculture of this State, has been presented by the Secretary, each year, in his last three annual reports. This necessity has been emphasized by the occurrence of several important Expositions, at which the interests of Pennsylvania agriculture were hardly noticed, owing to the fact that the State had no museum, or exhibit, upon which to draw. It is impracticable to collect the material, for a creditable display of the agricultural products of the State, in a single year.

The principles that should govern in the collection and preparation of a proper exhibit, or museum for agriculture, were set forth in detail in my last annual report, and inasmuch as the statement therein made, embodies my views, I take the liberty of quoting it in full.

"A modern Museum in agriculture, should not be a place for the mere piling up of material in order to fill space. It should be educational in its purpose rather than spectacular. To multiply bushels of grain or tons of vegetables, or devote time to the arranging of sheaves in fantastic forms, has no educational value. Any well conducted city market will show all this any day of the year. A great State Department of Agriculture, cannot afford to appear before an intelligent and discriminating public with the common-place, every-day productions familiar to every country child, but must make use of the advanced scientific knowledge of agriculture which exists, and exhibit the results of the application of this knowledge, in the producing of crops. An exhibition of wheat, for instance, should show

the plant in its stages of growth. The grain, the flower, the roots, the bran, the dust. There should be shown the starch, the gluten, the oil, the chemical constitution as affected by fertilizers, soil, moisture, sunshine; should show the soil and its constitution, the insects that affect the plant, the fungus diseases that attack it, the yield, the fertilizers adapted to its growth, together with an account of the rainfall which it received, the temperature during the period of growth, and all of the facts that had any influence in the production of the crop. Such an exhibition becomes a study, and is worth the time and attention of any man who is interested in knowing the best way to cultivate or manufacture this cereal.

An exhibit at any great fair, to be at all in keeping with the dignity of the State, should be arranged in Divisions, each in charge of a scientific expert, to prepare, and afterwards to oversee, while on exhibition. A Division of Cereals, one of Forage Crops, one of Live Stock, one on Dairy Products, others on Soils, Fruits and Fruit Husbandry, Vegetables, Flowers and Foliage Plants, Insects, Fertilizers, Poultry, Tobacco, Bacteria, Statistics. Such an exhibit properly prepared, arranged and explained, would be worth more to the farming public, than all of the train loads of products usually heaped up in agricultural buildings, at these great fairs. By having such an exhibit, placed in portable cases, it could be preserved from year to year and serve to interest and instruct agricultural people for a generation to come, and always be available for shipment to any part of the country where its presence is desired."

If the State is to be represented in its agriculture at the St. Louis Exposition, at least $25,000 should be appropriated to the Department of Agriculture, and the work of arranging for the exhibit, be begun at once. After the Exposition, such of the exhibit as is not perishable, could be returned to the Department, and be deposited in its museum ready for use for a similar purpose, in any future calls upon the State for a display of her products. Portions of the exhibit could be used, in representing the State at the several county fairs, in the manner suggested in another part of this report, under the head of county fairs.

In arranging for space in the new Capitol building for the Department of Agriculture, a large room is set aside for an Agricultural Museum. If, therefore, the appropriation were made this winter, and the work begun, the State would be creditably represented at the St. Louis Exposition, and at its close the room referred to would be all ready to receive the exhibit, to preserve it for the use of our citizens at home.

GOOD ROADS.

The absence of good public roads in Pennsylvania is the greatest obstacle now existing in the way of rural improvement. Ease of accessibility has become a necessity. Population will not even consider the question of locating in a district that cannot be readily reached from the cities and towns, and those living in a district which is shut out of communication with the world, will leave it as soon as opportunity offers. On the other hand, the fact that a community is furnished with rapid and reliable means of communication, invites the best and most progressive people to purchase homes there, and thus there is not only checked the flow of population to the cities, which has set in to an alarming degree, but it will increase country population, and do this by selecting the choicest citizens from the cities and towns of the State, so that the country will again become the abode of the culture and refinement of the land.

The difficulty in the way of securing these conditions is not that the country people do not appreciate good roads, or that they fail to see the great advantage which they will be to agriculture and rural life, but they have feared that the great expense which the construction and maintenance of good roads entail, will fall wholly upon them. If, however, the State will assume at least part of this burden, and ensure that no increase of tax shall be imposed upon farming people, there will not only be no opposition to the improvement of our roads, but such improvement will be gladly welcomed.

CITIES AND TOWNS BENEFITTED.

The delay in making an appropriation for this purpose by the State, has been largely due to a misconception of the purpose for which public roads are laid out. Many have felt that these roads were exclusively for the benefit of the residents who live along them and that, therefore, their construction and maintenance should fall upon these residents wholly, and all other citizens of the State be exempt from tax for their support. This view would have some degree of applicability if the same conditions existed now, as existed in the year 1800, when only a little over ten per cent. of the people of the State lived in the cities and incorporated towns, and ninety

per cent. lived in the country. Now, however, over fifty-six per cent. of our people live in the towns and cities and only forty-four per cent. in the country. This fifty-six per cent. are as much affected by the system of public roads in the country, in their capacity as distributing and collecting agencies for commerce, as are the country people who are located immediately along them. The cost of subsistence in the cities and towns is affected directly by the cost of transportation, and the cost of transportation is regulated, by the conditions that exist on the lines over which the goods must be carried. The cities depend wholly for supplies upon the transportation lines, not simply upon the great railroads and river boats, but upon the farm wagon and the country road. If these last are blocked, internal commerce in agricultural products soon must cease, and if they are so affected that only one-half of the normal tonnage can be transported, the cities feel the effect, and prices are correspondingly increased. Good roads, all through the country, ensure a constant and even supply of produce to the cities and towns during the entire year.

STEAM TRANSPORTATION COMPANIES BENEFITTED.

The railway and steamboat lines are also deeply interested in the improvement of the country roads, for reasons equally forcible and direct. They depend almost entirely upon produce collected at their stations, for their tonnage. If country roads are solid and in good repair, this supply is not affected by the climatic conditions which now seriously interrupt it. If good roads exist, communities, as has been stated, will increase in population, and as a consequence travel and production will likewise increase, and the surplus produce will go over the transportation lines to market. Since it is this local traffic that pays the best, its increase means the enrichment of these companies, directly due to the introduction of better public roads. All of the business interests of the State whether in city, town or country are interested, according to their investment, in seeing that better transportation facilities are provided for the country districts, to which they distribute their goods, and from which they draw their supplies.

The following States have recognized the duty of their government to appropriate money in aid of the improvement of their public roads: New York, New Jersey, Massachusetts, Connecticut, Maine and Vermont. Highway commissions are established in North Carolina, Michigan and Rhode Island. Constitutional amendments have been prepared providing for State aid in Minnesota, Wisconsin and California.

Pennsylvania is sadly behind these States in this respect. Her system of road supervision is unworthy of the Twentieth century.

A business that requires the best judgment, experience, and knowledge, to properly perform, is handed over to men, many of whom never even saw a good road, much less made one. Ignorance and incompetence are the rule. A law was passed by the Legislature of 1897 which would have remedied this, and given each district the opportunity of engaging in its service, for road construction, the best men which the community possessed. Unfortunately the bill was handicapped by a provision which required one million dollars to be first appropriated for road purposes before it could go into effect. The expense entailed in the erection of a Capitol building and the insufficient amount of State revenue for the purpose, prevented the making of the bill operative by the Legislatures which have since convened. The State is now in good financial condition, and there would seem to be no sufficient reason why this appropriation should be longer deferred.

The Act of 1897 provides for the election of three supervisors in each township to constitute a board. The election is for three years, one member going out of office each year and one new member being elected, thus forming a continuous board which is perpetual, and can be held responsible for any money which the State may see fit to place at its disposal. This board appoints road masters, who have charge of the work upon the highways, and are responsible to the road supervisors for the proper performance of their duty. The board is required to meet once each month, and for this each member is to be paid the sum of one dollar and a half for each meeting. The total expense of the board for its services for the year, is, therefore, fifty-four dollars. These supervisors plan the work and fix the tax; one-half of the tax is a work tax and the other half may be collected in money, if the board should so elect. Any business or professional man, therefore, can be road supervisor, not being excluded by the exacting conditions of our present system, which requires the supervisor to actually oversee the men at work. This supervisor-law does not take the control of the roads out of the hands of the community, but simply organizes boards which are responsible and continuous.

The appropriation of one million dollars for road purposes, or the repeal of the section requiring it, will carry the act into effect, and greatly assist in securing good roads for all of the districts in the State.

CONVICT LABOR ON ROADS.

Road construction by the employment of able-bodied prisoners convicted of crimes, and under sentence for short terms not exceeding ten years, has been successfully tried in twelve of the southern States and, to some extent, in California. The practice is, for the

courts to sentence such offenders to work on the public roads. The convicts are worked in squads of eight or ten men each, and are housed in a large steel van furnished with proper sleeping bunks and boarding facilities, and which may be hauled from place to place as occasion demands. If any seem disposed to be troublesome, and attempt to escape, they are prevented by the use of the ball and chain in day time, and by loosely fitting chain attached to hand or foot, and to a staple or rod at night.

Two sections of the North Carolina law, which is typical of the others, are given as showing the methods pursued in sentencing criminals to work upon the roads and the manner of securing their services by the township or city authorities who wish to employ them. The sections are as follows:

"Section 8. That prisoners confined in the county jail, under a final sentence of the Court for Crime, or imprisoned for non-payment of costs or fines, or under final judgment in cases of bastardy, or under vagrant acts, all insolvents who shall be imprisoned by any court in said county for non-payment of costs, and all persons who would otherwise be sentenced in said county to the State Prison for a term of less than ten years, shall be worked on the public roads of the county: Provided, That in case the number of such persons in any county, at any time, be less than ten, the Commissioner of the county may arrange with the Commissioners of any neighboring county or counties for such exchange of prisoners, during alternate months or years, as will enable each such co-operating county to thereby increase the number of prisoners at work on the public road at any given time. And upon application of the said road superintendent of the county, or that of the chairman of the Board of County Commissioners, the Judge of the Superior Court, or the Judge of the Criminal Court, the Justices of the Peace and the principal officer of any municipal or any other inferior court, it shall be the duty of the said Judge, or justice of the peace, or said principal officer, to assign such persons convicted in his court to said road superintendent or road supervisor in any township making provision for the same, for work on the public roads of said county or township; all such convicts to be fed, clothed, and otherwise cared for at the expense of the county or township, as the case may be: Provided further, That in case of serious physical disability, certified by the county physician, persons convicted in said Superior, Criminal, or inferior court, may be sentenced to the penitentiary or the county jail.

"Section 9. That when the Commissioners of any county shall have made provisions for the expense of supporting and guarding, while at work on the public roads of the county, or any township thereof, a larger number of prisoners than can be supplied from that county, upon application of Commissioners of said county, to the Judges of

the Superior and Criminal Courts, the justices of the peace and the principal officers of any municipal or other inferior court presiding in any other county or counties, which do not otherwise provide for the working of their own convicts upon their own public roads, shall sentence such able-bodied male prisoners as are described in Section 8 of this act, from such other counties to work on the public roads of said county, or townships applying for the same, in order of their application, and the cost of transporting, guarding, and maintaining such prisoners as may be sent to any such county or township applying for the same, shall be paid by the county or township applying for and receiving them, out of the road fund of each such county or township: Provided, That any and all such prisoners from such other counties may at any time be returned to the keeper of the common jail of such counties at the expense of the county or township having received and used them."

CONVICT LABOR LAW IN PENNSYLVANIA.

In Pennsylvania we have a law, passed at the session of 1899, and amended at the session of 1901, which gives authority to prison boards to require able bodied male prisoners to work on the public roads within the limits of the county in which the prison is located. This act should be amended so as to require such boards, to employ their prisoners in this service, and also provide for the procuring of prisoners for this purpose from other counties, when it is found desirable to do so. The same act could make it possible for the superintendents of our penitentiaries to apportion short term prisoners to the several counties, for road construction, and thus partly relieve the State of the burden of the expense of their food and clothing and at the same time assist the public in securing a much-needed improvement, without interfering with any of the rights of paid labor.

COST OF CONVICT LABOR.

The following table, showing the cost of labor per convict per day, in road work, is taken from the report of the National Department of Agriculture for 1901:

	Cost per day.
Florida,	$0 30 to $0 50
Georgia,	16 to 32
Kentucky,	50 to 60
Louisiana,	50 to 60
Mississippi,	15 to 45
North Carolina,	15 to 40
South Carolina,	17 to 22
Tennessee,	20 to 40
Texas,	20 to 40
Virginia,	25 to 50

These figures show, that the cost of convict labor in these States, is quite moderate, and experience shows that the amount of labor which they perform, is equal to that of the best hired service. These men are young, strong and active, and experience in penal institutions, is such as to show ,that most of the healthy prisoners would much sooner work than live idly in confinement.

The inmates of the penal institutions of the State of Pennsylvania in 1891, as reported by the State Board of Charities, numbered 8,189. They were distributed as follows:

	Males.	Females.	Total.
State Penitentiary, Philadelphia,	905	14	919
State Penitentiary, Allegheny,	658	20	678
County jails,	2,831	271	3,102
House of Correction, Philadelphia,	613	201	814
Allegheny County Workhouse,	660	93	753
House of Refuge, Philadelphia,	675	164	839
Pennsylvania Reform School, Morganza,	524	96	620
Pennsylvania Industrial Reformatory, Huntingdon, Pa.,	464	....	464
Total,	7,330	859	8,189

The cost of maintaining these convicts is given by the Board of Charities as follows:

	Total.	Cost per capita per week.
State Penitentiary, Philadelphia (1900),	$222,700 28	$2 68
State Penitentiary, Allegheny (1900),	285,973 44	4 95
Pennsylvania Industrial Reformatory (1900), County prisons, including workhouses,	133,677 36	4 79
House of Correction (1901),	939,644 12	4 27
House of Refuge, Philadelphia (1901),	182,109 99	3 08
Pennsylvania Reform School, Morganza (1901),	115,171 60	2 76
Total,	$1,879,276 79	....

Three-fourths of the male prisoners could well be employed upon the construction of highways for the Commonwealth, thereby relieving taxation and rendering beneficial service to the State.

CATTLE-FOOD CONTROL.

The work of the sampling and analysis of cattle-feeds, under the act of the Legislature of 1901, was begun this year, and the results are now ready for publication.

That part of the act regulating the work of the Department and prescribing the branding and analysis required, is printed in this report for information and is as follows:

"Section 1. Be it enacted, &c., That every lot or parcel of any concentrated commercial feeding stuff, as defined in section two of this act, used for feeding domestic animals, sold, offered or exposed for sale within this State, shall have affixed thereto, in a conspicuous place on the outside thereof, a legible and plainly printed statement clearly and truly certifying the number of net pounds of feeding stuff contained therein; the name, brand or trade mark under which the article is sold; the name and address of the manufacturer or importer, and a statement of the percentage it contains of crude fat and of crude protein, both constituents to be determined by the methods adopted at the time by the Association of Official Agricultural Chemists of the United States. Whenever any concentrated commercial feeding stuff is sold at retail, in bulk, or in sacks belonging to the purchaser, the agent or dealer, upon request of the purchaser, shall furnish to him the certified statement named in this section.

"Section 2. The term 'concentrated commercial feeding stuffs,' as used in this act, shall include linseed meals, cottonseed meals, gluten meals, maize feeds, starch feeds, sugar feeds, dried brewers' grains, malt sprouts, hominy foods, cerealine feeds, rice meals, ground beef or fish scraps, and all other materials of similar nature, but shall not include hays and straws, the grinding together of pure whole grains, nor the unmixed meals made directly from the entire grains of wheat, rye, barley, oats, Indian corn, buckwheat, or broom corn; neither shall it include wheat, rye or buckwheat bran, or middlings not mixed with other substances, and sold separately as distinct articles of commerce.

"Section 3. No foreign mineral substance, nor substance injurious to the health of domestic animals, shall be mixed with any feeding stuff sold, or offered, or exposed for sale in this State.

"Section 4. Each and every manufacturer, importer, agent or seller of any concentrated feeding stuff shall, upon request, file in the office

of the Secretary of Agriculture a certified copy of the statement named in section one of this act.

"Section 5. Each and every manufacturer, importer, agent or person, selling, offering or exposing for sale in this State any concentrated commercial feeding stuff, as defined in section two of this act, without the statement required by section one of this act; or affixing a statement or guarantee which is false in any particular, or in relation to which the provisions of all of the foregoing sections have not been fully complied with, shall, for every such offense, forfeit and pay the sum of one hundred dollars, which shall be recoverable with costs, including the expenses of analysis, by any person suing in the name of the Commonwealth, as debts of like amount are by law recoverable: Provided, That the Secretary of Agriculture shall, together with his deputies, agents and assistants, be charged with the enforcement of this act, and shall have full access to all places of business, mills, buildings, carriages, cars, vessels and packages, of whatsoever kind, used in the manufacture, importation or sale of any concentrated commercial feeding stuff; and shall also have power and authority to open any package containing or supposed to contain any concentrated commercial feeding stuff, and take therefrom samples for analysis, upon tendering the value of said sample; and whenever requested, said samples shall be taken in the presence of the party or parties interested or their representative, shall be thoroughly mixed and then divided into two samples and put in glass vessels and carefully sealed, and a label placed upon each vessel stating the name or brand of the feeding stuff or material sampled, the name of the manufacturer when possible, the name of the party from whose stock the sample was taken, and the time and the place of taking, said labels to be signed by the Secretary of Agriculture or his agent, and by the party or parties interested or their representative, if present, at the taking of the samples. One of said duplicate samples shall be retained by the Secretary of Agriculture or his agent, and the other by the party whose stock was sampled."

SAMPLES COLLECTED AND ANALYZED.

There were collected during the year 1902, under the provisions of this act, two hundred and sixty-three samples of cattle-foods. The samples collected, represented the following general classes of feeds:

	No.
Cottonseed products,	13
Flax seed products,	29
Wheat products,	12
Rye products,	4
Barley products,	12
Oat feeds,	9
Rice feed,	1
Corn products,	32
Mixed feeds,	33
Chops and feeds, composition not given,	86
Proprietory feeds,	31
Animal meal,	1
Total,	263

The samples taken represented 152 manufacturers and jobbers. There were 237 brands, taken at 124 places, and from 200 different dealers.

The samples were placed by the sampling agent in glass bottles provided with metallic screw caps, and containing a cork pad which fitted close to the top of the bottle, and were then sealed up in a carton and transmitted by express to the chemist. The analyses and examinations were made by Dr. Wm. Frear, Vice Director and Chemist of the State Experiment Station, and involved a large amount of painstaking labor. The determination of the character of the several grains, and adulterants used in feeds, is, of necessity, made by the use of the microscope, and requires accurate knowledge and familiarity with the forms of the several kinds of starch granules and fibre cells, of which these several substances are composed.

The time required for the careful examination of over two hundred samples, is very considerable. The approximate determination of the amount of the adulterants present, requires careful observation, and likewise consumes a large amount of the investigator's time. The work, therefore, is such as will necessarily, cause delay in securing results for publication, even after the samples are taken and placed in the chemist's hands.

SUMMARY OF RESULTS OF EXAMINATIONS.

The results of the examinations are summed up by the chemist, Dr. Frear, as follows:

1. "There is a considerable proportion of cottonseed meal selling under the grade 'prime' that is too dark to be admitted to this classification.

2. "Flaxseed meal is being sold under the same name, whether the fat has been removed or not.

3. "The term, 'oat feed,' is applied both to oat hulls, and to mixtures of the hull with chopped oats, but no oat feed examined, has the proportion of kernel found in the entire grain.

4. "A very large proportion of oat hulls appears in mixtures sold under the general names of chop, mixed feed, etc.; there is, in such case, no technical misrepresentation; nevertheless, in the absence of a statement of composition as required by law, the consumer is buying a very large volume of inferior feed, without due notice. This substitution of oat hulls for oats, appears also in feeds sold under names indicating that the materials are made by mixing the entire grains.

5. "Cob meal has been found as an adulterant of wheat feed.

6. "Many of the feeds contain many weed seeds, sometimes in a whole condition; buyers should be watchful against such materials.

7. "There is not only a very general failure to comply with the legal requirements as to guaranty—which will doubtless be remedied as the trade becomes better acquainted with these requirements and more fully aware of the advantage which such guaranty eventually gives to all honest dealers; but there is a too general failure to meet the guaranty given. This is doubtless to be explained in part by the lack of careful chemical control over the mixing operations; but the deficiencies occur in too large a proportion of the cases, to admit this explanation for all the observed instances."

During the past year our agent was frequently met by millers or dealers as he asked for a sample, with the remark, that "this was the first knowledge they had of the existence of such a law." They, however, as a rule, have expressed their approval of its provisions, and have agreed to so brand their goods in the future, as to comply with its requirements.

The value of the law, in protecting purchasers of cattle foods against adulteration, cannot be estimated, but that it will be very great, is clear, from the fact, that, previous to its enactment, our State had become the dumping ground for all sorts of adulterated feeds, whilst now, with a single year's effort in the enforcement of the law, the majority of the feeds have been brought up to the standard guaranteed.

AGRICULTURAL EDUCATION.

It is not to be expected that the time will ever come, when every farmer will be a graduate of a College of Agriculture, or that ever a majority can be so educated. The time, however, ought to come, and come soon, when every farmer's child will have opportunity for obtaining a knowledge of the elements of the natural sciences which relate to the farmer's life and occupation.

All that is needed, is to plant a graded school in each district, equipped with proper teachers and appropriate apparatus, to accomplish this result. The old single-teacher-district-school is no longer competent to give the amount and variety of instruction needed by country children. The teacher who, with the present limited curriculum, is obliged to hear twenty-seven classes each day—which is the average for the country teacher in Pennsylvania—cannot be further burdened with additional work, no matter how important, or how urgently needed, such additional instruction may possibly be. The country teacher has reached his limit of physical endurance, and the imposition of further work must result in the slighting of present studies, which even now, owing to the conditions named, are inadequately taught.

Give the country teacher the same chance in the number of classes which he shall hear, that his city cousin has, and his scholars the same opportunity for gaining knowledge that the city children now enjoy, and there soon will be such an impetus given to country living and its occupations, as will revolutionize agriculture, and speedily stop the flow of her best blood away from the farms, to be, alas, too often corrupted and lost, in the great putrid sea of city life.

THE COMMITTEE OF TWELVE.

At a meeting in Denver, Colorado, in 1895, the National Council of Education, appointed, what has now become known and famous, as the "Committee of Twelve on Rural Schools." This committee, composed of Henry Sabin, D. L. Kihle, A. B. Poland, C. C. Rounds, J. H. Phillips, B. A. Hinsdale, S. T. Black, W. S. Sutton, L. E. Wolfe, W. T. Harris, L. B. Evans and C. R. Skinner, leading educators in the United States, after a very exhaustive examination of the whole subject of education under country conditions, reported to the association, in a volume of over two hundred pages, the results of their inquiry and the conclusions reached.

The learned character of this committee gives its recommendations a value, greater than those of any other authority in this

country. I therefore quote some of their conclusions, relating to rural schools, and the methods which should be adopted for their improvement.

The report states that "About one-half of all of the teachers in the United States, teach what are called Ungraded Schools. They receive in one room, pupils of all ages and all degrees of advancement, from A B C's upward, sometimes even to algebra and latin. In extreme cases, each pupil is a class by himself in all branches except, perhaps, reading, writing and spelling." * * * "It happens that ungraded rural schools with very small attendance are to be found even in the most thickly populated States and often in proximity to cities." "New York in 1894-5 reported 2,983 schools with fewer than ten pupils each, and 7,529 with less than twenty." * * * "A school with ten pupils, of ages from five to fifteen years, of different degrees of advancement, some beginning to learn their letters, others advanced from one to eight or nine years in the course of study, cannot be graded or classified to advantage, but must for the most part be taught individually. The beginner who does not know a letter, should not be placed in a class with another who began last year and can now read lessons in the middle of the primer. It will not do to place in the same class, a boy beginning numeration, and another one who has already mastered the multiplication table. The beginner in grammar has not yet learned the technique, and is confused and discouraged by the instruction given to another pupil in his class who has already learned the declensions and conjugations. Any attempt, in short, to instruct two or more pupils in a class, when there is a difference of a year's work in their advancement, results in humiliating and discouraging the less advanced, and in making the maturer pupils conceited." * * * "The teacher, even after forming classes in writing, reading, and spelling, has twelve to fifteen lessons to hear in a forenoon, and nearly as many more for the afternoon. There is an average of less than ten minutes for each recitation." * * * "The teacher cannot probe the pupil's knowledge in five minutes and correct his bad habits of study, nor in ten minutes. In the necessarily brief recitations of the ungraded school, there is barely time to test the pupil's mastery of the external details of the lesson, the mere facts and technical words. It is for this reason, especially, that the rural school has been the parent of poor methods of instruction—of parrot memorizing, and of learning words, instead of things." * * *

THE IDEAL CLASSIFIED SCHOOL.

"In the ideal classified school, the teacher has two classes of pupils, each class containing within it, pupils substantially at the same stage of advancement. The pupils of a given class

recite together in all their branches, and the teacher has a half hour for a lesson, and can go into the dynamics or casual relations of the facts and events treated." * * * "The ideal classified school can teach, and does teach, proper methods of study; the rural school cannot do this effectively in its five or ten minute recitations. It is because of this, that wise directors of education have desired the consolidation of small schools into large schools, wherever practicable. Two schools of ten each, furnish on an average one-half as many recitations, if united, as they do when separate, owing to the possibility of pairing, or classifying pupils of the same degree of advancement. Ten such schools united into one will give 100 pupils, with a possibility of classes of ten each, which can be more effectively taught than before, because the pupil can learn more in a class than by himself." "Again it is evident that five teachers can teach the 100 pupils united in one school, far better than the ten teachers were able to teach them in ten separate schools. If still further consolidation were possible, and 400 pupils were united in one school, the classification might be improved to such a degree that a teacher could easily take charge of two classes of twenty pupils, and ten teachers could do far better work for each pupil, than was done by the forty teachers in the forty small rural schools, before consolidation. Herein economy becomes a great item in what are called 'Union Schools.'"

THE TRANSPORTATION OF CHILDREN.

The committee in discussing the question of the transportation of children to central schools says: "The collection of pupils into larger units than the district school furnishes, may be accomplished under favorable circumstances by transporting at State or local expense, all of the pupils of the small rural districts to a central graded school, and abolishing the small ungraded school. This is the radical and effective measure which is to do great good in many sections of each State. As shown already, Massachusetts, in which the plan began, paid in 1894-5 the sum of $76,608 for the transportation of children from small rural schools to central graded schools —213 towns (townships) out of a total of 353 towns (townships) and cities, using this plan to a greater or less extent, and secured the two-fold result of economy in money, and the substitution of graded for ungraded schools. The spread of this plan to Maine, Vermont, New Hampshire, Connecticut, Rhode Island, New Jersey, Ohio and some other States demonstrates its practicability. Experiments with this plan have already suggested improvements, as in the Kingsville experiment in Ohio, where the transportation reached in all cases the homes of the pupils and yet reduced the cost of tuition

from $22.75 to $12.25 for each of the fifty pupils, brought to the central school from the outlying districts." The committee in its summary says: "One of the great hindrances to the improvement of the rural school, lies in its isolation, and its inability to furnish to the pupil that stimulative influence which comes from contact with others of his own age and advancement. The committee therefore recommends collecting pupils from small schools into larger, and paying from the public funds for their transportation, believing that in this way better teachers can be provided, more rational methods of instruction adopted, and at the same time the expense of the schools can be materially lessened."

These are some of the conclusions of this eminent committee, whose report was read before, and accepted by, the National Educational Association of the United States.

Two years ago this Department sent a qualified expert, to make investigation into the working of the system of the consolidation of schools and the transportation of scholars, where it had been thoroughly tried, and his report, giving the conditions under which these centralized schools were operated, and the service they are rendering, shows that they are not only much more efficient from the educational standpoint, which is of course the great purpose in the establishment of any school, but are at the same time more economical in expenditure than the isolated school.

Mr. A. B. Graham, township superintendent, Springfield, O., writes that in his State "nearly forty townships are to-day solving the country school problem by centralization, and the formation of graded schools." He states that in "such a school the township becomes a stronger unit for local government, than it can become under a system of isolated schools. A boy or girl grows up a member of the society of the township, instead of an acquaintance of a few families." Dr. A. C. True, Director of the Office of Experiment Stations, writes in the report of the Department of Agriculture for 1901, "The movement for the consolidation of small schools, has already been in progress long enough to have demonstrated, that when properly managed, it will produce excellent results; that in eighteen States, transportation of pupils at public expense, is already permitted by law."

CENTRALIZATION OF RURAL SCHOOLS IN PENNSYLVANIA.

Pennsylvania, I am glad to be able to say, has enacted such a law. It now remains for those who are interested to call attention to its importance, and to strive to carry its provisions into effect. Some progress has been made, although the act is not yet two years in

force. Several townships have taken initiatory steps in the direction authorized by the law, and two or three others have adopted the system and are now transporting the scholars to their central schools. North Shenango township, Crawford county, and Herrick township, Susquehanna county, are now solving this problem in Pennsylvania.

The county superintendents in thirteen counties in Pennsylvania, in their reports to the State Superintendent of Public Instruction in 1901, called attention to the consolidation, as being the solution of the rural school problem. Inasmuch as the progress of this movement is fairly indicated by these reports, I quote from them for information:

Prof. T. H. Morrison, Superintendent of the Erie County schools, says: "There is a greater sentiment in favor of the consolidation of our rural schools, and the establishment of the township high school in a good many districts. In Springfield, Elkcreek and Millcreek, schools are closed on account of small attendance, and the pupils are transported by means of vans to a central school. This centralization of schools is a great improvement over the old system. Some of the advantages are: The percentage of attendance is very much increased; there is less sickness; no tardiness among transported pupils; a much larger percentage of children enrolled; better teachers employed; principals are employed to supervise; more interest and enthusiasm on the part of both pupil and teacher; it costs very much less, and the children have the advantage of a higher education."

Prof. Eli M. Rapp, Superintendent of Berks County schools, states as follows: "There are certainly forces at work in society, which will ultimately rescue the rural school from its present low state. The increased demands for better roads, for rural postal delivery, for cheaper telephone and telegraph rates, for school consolidation and transportation, for township high schools, will eventually bring the country school out into the full light of a brighter day."

In speaking of the recent appropriation for the establishment of township high schools, Prof. T. L. Gibson, County Superintendent of Cambria county, makes the following statement: "In this connection, we believe it to be in place to quote from the principles expressed by the National Educational Association, at the meeting in Detroit a few days ago. In its 'Declaration of Principles,' one reads thus: 'The National Educational Association watches, with deep interest, the solution of the problem of consolidating rural schools, and the transporting of children at public expense, now at-

tempted in many of our leading States. We believe that this movement will lead to the establishment of the country high school, and thus bring more advanced education to rural communities. We also believe that supplementary State support with rural high schools is in the highest interest of the entire State.' This is the expression not of a body of educators in a single State, but of a National body, and the latest educational legislation in Pennsylvania, is in accordance with this principle."

The Superintendent of Bradford county, Prof. H. S. Putnam, in his report, says: "The problem that confronts the schools in the country districts, and which seems difficult of solution, is the fact that the population is so changed, that there are hardly pupils enough to warrant the continuance of many of the schools. In one district there were four schools, with a total enrollment of thirty-eight, while in another school, in the same district, there was an enrollment of forty-five. Many schools have only four or five pupils, and as much money is expended for the maintenance of these smaller schools as for the larger ones. It seems that there is only one way to do, that is to establish a central school and transport the pupils from the smaller schools to the larger ones."

Prof. W. R. Longstreet, Superintendent of Tioga county, reports: "The question of the centralization of rural schools is a live question in many districts of this county. Public sentiment is growing in that direction. Two or three districts at least are about ready to make the experiment. This question was readily entertained by some, on the ground that it would be cheaper in the sense of requiring less taxation, but more deliberation and investigation has convinced them, that the economy of the scheme will not be in less expenditure of the public funds, but in greater and better advantages that would be given to the youth of the district, and I am very sure that with only the latter purpose in mind, can the plan ever be made a real success."

Superintendent Miller, of Columbia county, states, in speaking of the town schools: "But is it right that our town schools shall gain strength at the expense of the country? While we are heartily in favor of a centralized system of rural schools, at the same time we are fully impressed with the opinion, that the time is not yet for the complete realization of our dreams."

Superintendent Sweeney, of Elk county, reports: "That during the year many graded school buildings were erected throughout the county, and at present all districts have one or more graded schools, where children have an opportunity to thoroughly master the common

school course, and also gain a fair knowledge of some of the higher branches of study. Over 80 per cent. of the pupils of the county attend graded schools, and the next year will show a material in crease in the number, as there is a growing spirit favorable to centralization in all our districts."

Prof. J. S. Fruit, Superintendent of Schools of Mercer county, states: "I think that township centralization of schools will solve two great problems for the rural school. The present inability to maintain anything like a course of study for the ungraded common school, and for the close relations between the now isolated rural teacher and the county superintendent. In my county, where I am required now to make over 200 calls in the thirty-one townships, were they centralized, I could make at least 600. Hasten the day when we have centralized township schools."

Prof. Horace L. Walter, Superintendent of Monroe county schools, reports: "We believe that better results might be obtained in the matter of school work by consolidating, and establishing graded schools in the several parts of the county. There are districts in which this could be done with but little inconvenience to the children, and when once established, with less expense to the district. When a large number of scholars of all grades are gathered together, the best work can be done. The teacher knows it, and the scholars also understand that they do not receive the attention to which they are entitled. Very often they lose interest in the work, and drop out of school at the first opportunity."

Superintendent Hoffecker, of Montgomery county, reports: "The schools need closer supervision, and the school sentiment is ready for it. The best provision that could be made, would be the establishment of centralized high schools, with transportation for pupils. The cost of transporting could be saved in the fewer number of schools. The children from remote parts of a district would enjoy the same privileges as the children in a village, and all would have the benefits derived from a skilled teaching force."

Superintendent Apple, of Northumberland county, reports: "It is the universal opinion of more thoughtful people, that the law providing for the centralization of rural schools, and the establishment of high schools, is as far reaching a step in the school system of Pennsylvania, as has been taken since the system itself was adopted."

Prof. Chas. E. Moxley, of Susquehanna county, states: "Far from me to cast any reflection on the work of the rural school as it has existed for now nearly half a century, but the conditions under

which they were organized have so changed, as to demand a readjustment of the old; not to destroy it, but to reorganize it; not to lessen its influence, but to increase it; not to narrow its work, but to broaden it; not to belittle its power, but to encourage it in ways it never before possessed. What, then, is the seeming solution of the problem? To my mind, as well as to the minds of many friends who have given it serious thought, it is the consolidation of schools and the transporting of pupils at public expense. There is no tramping through snow and mud, and the attendance is greatly increased, and much more regular. The item of expense I pass over in this report, but no one, even the most critical, need hesitate to approve on account of the expense. We should not consider school questions alone from the standpoint of expense. School work is not unlike other things; we cannot get something for nothing, but it can be proven to be a positive saving to the taxpayers, at the same time offer advantages to every rural school pupil, as good as those now enjoyed in towns or villages. If centralization is a good thing, we want it; if it is not, we want to know why it is not."

Prof. Gramley, Superintendent of the schools of Centre county, reports as follows: "The centralization of rural schools, which comprehends township high schools and free transportation of pupils, is legalized. Let us try to create a sentiment in favor of both of these laws, and we will ultimately have better houses, more adequate school apparatus, increased attendance, fewer but better teachers with higher salaries, better grades, more effective supervision, and possibly an enlarged curriculum, yet a reduction in the total cost. If the principle of concentration is permissible in the business world, why not apply it to the rural school question?"

These superintendents make these several reports, giving their estimate of consolidation, and unanimously endorse it. Surely the sentiment in favor of centralization of rural schools in Pennsylvania is growing, and needs only a little encouragement to rapidly spread over the entire State.

The way is now open for the improvement of our rural schools, and it is incumbent upon all who believe in giving the country boy and girl a chance, to devote some time and effort to instructing those who now are undecided what is best to do. Let the truth be faithfully and clearly stated, *that there can be no material improvement of the country schools without consolidation, and that there can be no great advance made in our agriculture, until better rural schools are provided.*

The future farmer must have a knowledge of the science of agriculture if he would succeed in the competition that has set in,

which means, that he must be educated in the sciences that underlie his art. This knowledge the great mass of farmers cannot secure, unless it is given in the public school, and it cannot be given there, for the reasons that have been stated, until the schools are graded, and more time is given to the teacher to do his work. One would suppose from the spirit of content that exists among those who have the management of our rural schools, that we had reached perfection, and that there is nothing further to be desired or possible to be obtained. A visit to any well conducted city school will soon dispel this illusion. They demonstrate, every day, that scholars can be fitted there for entrance to the freshman or sophomore class in any college in the land, and that this not only can be done, but is done, in the same time in which the country child is at work upon the rudiments of an education, in the ungraded country school. The one has full opportunity and advantages, the other has a most meagre apportionment of each.

The report of the Superintendent of Public Instruction for 1901 shows that there are over ten thousand (10,348) ungraded schools in Pennsylvania. All of these, with few exceptions, are in the country. It is distressing to see these thousands upon thousands of country children, who ought to have, and could have, as fine an education as any in the land, denied the privilege, and forced to be content with the elementary training of an ungraded country school, or else leave their homes and incur the additional expense of tuition, board, and room, in some town or city, where the system of education is adapted to children's needs. In the days of ignorance of better methods, this apathy was entitled to some excuse, but now, in these days of enlightenment, of progress and better knowledge of what is possible to be done, it is a crime to sit unmoved, when our groping children cry to us for light.

AGRICULTURAL ORGANIZATIONS.

The number of these societies in the State was given in my last annual report, as was also a brief mention of the history and purpose of each. It is therefore unnecessary to repeat what has been published, and I now refer to them for the purpose of calling attention to their needs and their services to the State. They are all voluntary in their character, but their service is a public service which is greatly to the advantage of the agricultural industry of the country.

The County Agricultural Societies, The State Agricultural Society, The State Board of Agriculture, The State Horticultural Association, The Dairy Union, The State Live Stock Breeders' Association, and the State Poultry Association, have each contributed to the present prosperous condition of agriculture in Pennsylvania, by their intelligent and unselfish efforts in the several directions indicated by their respective names. The State ought to take a deeper interest in making these societies more useful and influential by appropriations suitable to the needs of each. The Constitution of the State forbids the granting of appropriations directly to institutions of this character, not under State control, but it is perfectly lawful and proper, to grant an appropriation to the Department of Agriculture, to be used for the purpose of furthering the interests of any one or all of these institutions.

Some of them at present need only enough to pay for the expense of the hall in which they meet, and the preparation and publication of their proceedings and reports. Others need a certain guarantee, to meet, to a limited extent, the cost for premiums offered for the encouragement of exhibitors, and to protect the officers of the society against personal loss in case their receipts are insufficient to pay the premiums. Payments by the State for this purpose, should be restricted to premiums on subjects which are approved by the Secretary of Agriculture, as being of a character calculated to promote the public good.

There is little danger to be apprehended from the granting of such an appropriation, for the character of the membership of these organizations is such, as to guarantee, that the funds so granted, will be discreetly used, and not be misapplied. Full and detailed reports should be required of these societies ,and all bills should be approved by the Secretary of Agriculture before being paid.

COUNTY FAIR ASSOCIATIONS.

Attention is especially called to the field of usefulness open to the fair associations in the several counties of the State. There are seventy-eight of these societies, with over 9,000 members; all public spirited, active, intelligent men, and they reported last year an attendance of over one million of people. It is certainly of extreme importance that these organizations shall use their efforts and their influence so as to be of the greatest possible usefulness to the agriculture of the Commonwealth. It is unfortunately true, that very many of them fall far short of what they should be, as promoters of agricultural education, or as setting a high moral standard to the visitors whom they invite to attend their fairs.

THE MIDWAY EXHIBITS.

This Department sent out a letter of inquiry two years ago, asking, among other things, what the Department could do to aid their society in the prosecution of this work. The almost uniform reply was "help us to pay our premiums." The necessity for securing money to pay the premiums offered, drives these organizations to grant concessions to disreputable shows and gambling devices, which are a disgrace to any society, which pretends to be at all concerned for purity of thought among our people, or good morals in society. Obscene dances by half dressed actors, open gambling, loud, coarse speeches by fakirs who have monstrosities on exhibition, are some of the sights and sounds that greet refined and modest women and children, who come to be instructed and entertained. All of this under the guise of an agricultural exhibition for the improvement of this industry.

Trials of speed, acrobatic and sleight of hand performances, exhibitions of trained animals, or the admission of the merry-go-round, or of games of ball, foot races and athletic sports, and similar amusements, are all unobjectionable when properly controlled, and will provide entertainment to those who come to spend an idle hour. The others are most immoral and corrupting, and ought to be excluded from every fair.

The original purpose of the county agricultural fair was to place on exhibition samples of products of the country, mainly of its farms, which were unusually perfect of their kind, bringing them into competition with each other, with the view of improving agriculture in all of its diversified interests. The offering of premiums, was intended to act as an incentive to producers, to bring out their products, with the assurance that if they had the best, they should be rewarded to the extent set down in the premium list for that class of exhibits.

For many years these fairs were largely attended, and their good effect was seen in the increased interest that was excited by the exhibits there displayed. Gradually this feature of the old-time fair came to be supplanted by the public horse and cattle sale, and the town and city market. At the latter could be seen daily, a great variety of fruits and vegetables prepared in attractive style, and of the best quality known. As a consequence, the mere display of corn and wheat and vegetables became very common, and to a great extent lost its power to attract. Horses and cattle still hold their own, and implements, for the purposes of the farm, particularly if they are in motion, are a never failing source of interest to all. Choice fruits are still of interest if carefully selected and well marked, and exhibited by a man who understands his business. In fact, it has come to substantially this, that any article or exhibit, unassisted by an exhibitor, is not likely to secure more than a mere passing notice. If it be at all worthy of a place inside the enclosure of a county fair, it must not be left to tell its story for itself, but ought to have a competent expert to explain its peculiar virtues, and if an implement, show the visitor how it works. A county fair properly equipped, and with twenty capable men and women to show it off, will be a success, without the aid of fakirs or disreputable shows.

EXHIBIT SHOULD BE EDUCATIONAL.

A county fair should, first of all, be educational. If this feature is properly developed there can then be associated with it sufficient suitable entertainment to add to the variety and interest, and to remove any temporary dullness or monotony that may exist.

Fair managers must recognize the fact, that their visitors want to be kept busy seeing and hearing things that are out of the common. Accordingly, they must strive to secure this interest by the introduction of high grade articles, and place with each class, some one who knows how to call attention to the superior quality, which each article possesses over others. If some farmer has raised forty bushels of wheat to the acre, he will have plenty of auditors, if he will tell how he did it, or how it may be done by others. If some one has developed a herd of dairy cows, from a production of 120 lbs. of butter per year to 400 lbs. per year, he will not lack for interested hearers. It is the unusual that attracts and interests, and it is the unusual that must be presented, or the fair will fail, both as to the number of those who attend, and in its educational value as well.

STATE AID.

The question arises, how can this be secured without resorting to sensational and disreputable shows? I suggest that the State appropriate to the Department of Agriculture for the development

and improvement of county agricultural fairs, the sum of $25,000 per year, or so much thereof as may be needed. Let the Secretary of Agriculture district the State into six districts of eleven counties each. Begin the fairs in each circuit on the Monday of the last full week of August, and continue them to the close of the first full week of October, holding two fairs of three days each, every week, in all of the sections. Let the Department send one competent man to each fair as its representative, who shall have charge of an exhibit to be furnished by the Department, and also to make report upon the general character of the fair, its exhibits, its freedom from, or the presence of, objectionable shows or entertainments. Let the Department prepare and publish a list of articles for which it will offer premiums of amounts to be designated; the degree of excellence of the articles to be passed upon by a committee of experts, and the award to be approved by the representative of the Department, assigned to that circuit. The total of the premiums to be awarded by the Department at any one fair, not to exceed the sum of $400.00, and in no case to exceed the sum offered and paid by that society, for premiums upon articles of similarly useful character, and in no case shall any premium be offered by the Department, unless the managers of the society shall agree, in advance, to exclude all objectionable shows and gambling games from their grounds. Only one fair association in each county to be entitled to the premium offered by the State in any one year, and where two or more apply for recognition, the one to be aided shall be that one, which paid the greatest amount in premiums the preceding year, for items approved by the Department ,and not including those offered for trials of speed.

The encouragement and strength which such support will give to agriculture, will not only be returned to the State many times by the increased production that such exhibitions will necessarily effect, but will also rid these fairs of disgraceful exhibitions by fakirs and lewd showmen, and restore the old-time purity that is sadly lacking in many of the so-called agricultural exhibitions throughout the State.

SPHERE OF INFLUENCE.

At present, the exhibition—limited to but one a year—is the only sign of life that most of the fair associations display. Three or four days of activity, and then a year of idleness and silence. A fair association ought to be alive, active and interested in aiding agriculture, at all seasons and every day in the year.

The directions in which it can be useful are many. For example: It can take an interest in the improvement in the public highways; in the education of its citizens, and of its supervisors of roads in the

latest and best methods of road maintenance and construction. It can insist that the rural schools shall be suited to the needs of the country children, and it can use its influence to retain good teachers, and to secure the dismissal of the incompetent or bad. It can stimulate the improvement of country homes and their surroundings, by holding meetings and inviting citizens to attend and discuss methods for beautifying the home, and means for the production of better crops.

Another and very important service that these societies can render to the citizen of every county, is in the giving of assistance to those who are interested in, and are engaged in rearing better stock. The difficulty that confronts farmers, in many counties, who wish to improve their stock, is the impossibility of securing the service of well bred sires. The country is full of cheap scrub horses, cattle, sheep and swine. They are scrub, because they sprung from cheap scrub sires. There can be no improvement in our stock until well bred sires are introduced, and their services be had at rates low enough to be within the reach of the farmer of ordinary means. The county fair associations could do no better service to their county than to purchase, or hire the use of, one or two well bred sires of each of the leading breeds of horses, cattle, sheep and swine, and have them kept for service at moderate rates, and offer this service at these reduced rates to those only who are members of the fair association, thus inducing the more progressive farmers to join the society, and aid in its support. There is no reason why this cannot be done, and at the same time be a source of revenue to the association. As an inducement to undertake this, a portion of the money to be given by the State could be offered to such association as will maintain a breeding barn of well bred sires.

LIVE STOCK IN PENNSYLVANIA.

The live stock of Pennsylvania represents in value about $126,-000,000. A slight improvement upon each animal would add enormously to the wealth of the State. The following table gives the number, and average value of each class of live stock, taken from the last census report, and shows the amount of increased value, which could be secured, if the animals were so improved, as to bring the small additional sums set down in the fifth column of the table. The additions aggregate almost $17,000,000.

Viewed as a purely business proposition, the State cannot do better than to supply the slight aid, that is necessary to bring about this result.

Live Stock.	Age in Years.	Number.	Average value.	Add to present value.	Increase.
Calves,	Under 1,	421,323	$7 20	$1 00	$421,323 00
Steers,	1 and under 2,	108,681	16 01	2 00	217,362 00
Steers,	2 and under 3,	64,252	29 62	5 00	321,260 00
Steers,	3 and over,	16,382	43 51	8 00	130,656 00
Bulls,	1 and over,	69,006	23 29	10 00	690,060 00
Heifers,	1 and under 2,	224,623	16 50	3 00	673,869 00
Cows kept for milk,	2 and over,	943,773	30 88	5 00	4,718 865 00
Cows and heifers not kept for milk,	2 and over,	48,807	25 02	5 00	224,035 00
Colts,	Under 1,	28,547	28 26	5 00	142 735 00
Horses,	1 and under 2,	36,584	52 39	8 00	292,672 00
Horses,	2 and over,	525,850	72 69	10 00	5,258,500 00
Mule colts,	Under 1,	1,144	40 10	8 00	9,152 00
Mules,	1and under 2,	3,604	58 35	10 00	36,040 00
Mules,	2 and over,	33,311	79 60	15 00	499,665 00
Asses and burros,..	All ages,	576	39 16	5 00	2,880 00
Lambs,	Under 1,	571,583	2 32	50	258,791 00
Sheep, (ewes),	1 and over,	769,463	3 45	1 00	769,463 00
Sheep (rams and wethers),	1 and over,	109,020	3 49	1 00	190,020 00
Swine,	All ages,	1,107,981	5 26	1 00	1,107,981 00
Goats,	All ages,	2,197	4 07	75	1,646 75
Chickens,		10,553,106		05	527,655 30
Turkeys,		259,824		15	38,973 64
Geese,		60,780		15	9,117 00
Ducks,		171,271		10	17,127 10
Bees (swarms),		161,670	3 29	1 00	161,670 00
Increase,					$16,768,518 79

The foregoing statement shows the results possible to be obtained by the encouraging of but a single branch of our agriculture. This can be multiplied, if the same assistance and encouragement is given in the other branches, such as fruit growing, grain raising, vegetable gardening and kindred crops, suited to our latitude and soil.

EXPENSE OF THE STATE BOARD.

There should also be an appropriation made to pay the expenses of the annual meeting of the State Board of Agriculture, the Horticultural Society, the Dairy Union, the Live Stock Breeders' Association, and the Poultry Association. Twenty-five hundred dollars per year, would pay the expenses of the meetings of all of these organizations ,and would relieve the individual members from being compelled to contribute, of their private funds, for this purpose. The work of these societies is of public importance, and the State can well afford to aid them in their efforts to develop the branch of agriculture which each represents. Twenty-five hundred dollars per year would meet this expense. Our sister State, New York ,gave in 1902, for these purposes, as follows:

To the State Fair Commission,	$74,398 85
For the payment of premiums at the State Fair,	25,000 00
For the payment of premiums to County Agricultural Societies,	66,000 00
The State also contributes, for the same purpose, the amount received from racing associations, which reached,	98,000 00
Making a total of,	$263,398 85

The result of these expenditures, is seen in the progress which all of these organizations are making in New York State, and in the great impetus that has been given to all branches of her agriculture.

Ohio appropriates $20,000 annually to the support of her State Fair, and under their law the county agricultural societies are entitled to two cents per capita, from their counties, not to exceed $800.00 in any one county. The State Horticultural Society receives $1,000 a year and the State Dairymen's Association receives $1,000 annually.

Pennsylvania appropriates nothing for these purposes, and is in consequence behind these other States which border us, in her development of these interests of her agricultural people.

PRICES OR FARM PRODUCE, LAND AND LABOR.

The Department collects and publishes statistics each year, showing the wages paid for labor throughout the State, and the prices of farm crops, animals, and land in all of the counties. A detailed report on these subjects is given in the report of the Deputy Secretary, who has charge of the collection of these statistics. The general averages of prices for the year are as follows:

Wheat,	$0 76
Corn,	62
Oats,	44
Potatoes,	54
Clover hay,	11 33
Timothy hay,	14 25
Butter,	24
Ewes,	3 50
Lambs,	2 75
Horses,	111 88
Cows,	33 22
Chickens per lb. (live),	10
Chickens per lb. (dressed),	13
Labor per day with board,	1 25
Farm land per acre, improved,	55 00
Farm land per acre, average quality,	34 00

These prices are, in nearly every case, in advance of those of last year.

LEGISLATION NEEDED.

The following items of legislation are, in my opinion, needed by the agricultural interests of the State, most of which have been discussed in the body of this report, and are collected here for reference:

For the purpose of assisting in the construction and maintenance of country roads, $1,000,000.

For the purpose of providing premiums for the assistance of county fairs, per year, $25,000.

For the purpose of securing an Agricultural Museum, and for an agricultural exhibit at the coming St. Louis Fair, $25,000.

Increased appropriation to the Farmers' Institute work, additional per annum, $10,000.

For the purpose of securing an Agricultural Library for the Department of Agriculture, $3,000.

For the purpose of paying the expenses of the Annual Meetings of the State Board of Agriculture, the Horticultural Society, the State Poultry Association, and the State Live Stock Breeders' Association, per year, $2,500.00.

To provide for the erection of a Division of Animal Husbandry in the Department of Agriculture.

To provide for the erection of a Division of Horticulture and Pomology in the Department of Agriculture.

For the erection of a Division of Public Highway Improvement in the Department of Agriculture.

To extend the authority of the Secretary of Agriculture to publish farmers' bulletins to a number not exceeding 25,000 copies of any one bulletin.

To provide that in the distribution of the Annual Reports of the Department of Agriculture, five thousand copies shall be given to the Department for its use.

CONCLUSION.

In concluding this report, I desire again, to express my sense of obligation for the cordial and effective support which you have given me during your administration. It would have been impossible for me to have performed the duties of Secretary of Agriculture of this State, if it had not been for your confidence and encouragement. How varied and important the duties of this office are, can to some degree be imagined from the report itself. The Department has to deal with the most difficult questions which science has to meet, and is also brought in practical and personal contact with the great commercial interests of the country. The administration of the food laws alone, requires exceeding care-

fulness lest wrong be done, and firmness lest wrong be allowed. In the control of food substances the Department must understand the intricacies of the trade, and the chemical composition of substances, in order to properly decide what course ought to be pursued. The public health is to be protected at all hazards, and at the same time the manufacturers and dealers must be given fair opportunity to show the beneficial qualities of their goods without undue annoyance or molestation. The preparing of proper food laws and the securing of their enactment are important features of the Department work. This, however, is but a single Division of the work to be accomplished by the Department.

In the Division of Veterinary Science, the public are protected against the inroads of contagious or infectious diseases among our domestic animals. The recent outbreaks of "foot and mouth disease" in some of the New England States is a single instance of the danger to which our live stock industry is exposed. This Division of the Department is the only safeguard the State has against these diseases that appear from time to time, and which, if unrestrained, will certainly destroy our herds.

The work of the Department in inspecting Nurseries, has also been of great benefit, in protecting our orchardists against the introduction of destructive insect pests, and dangerous diseases which abound on every side. There are also the analyses of Commercial Fertilizers, for the protection of the public against imposition and fraud, and the inspection and analysis of Cattle Foods for the same purpose; all directly in the interests of agriculture, and constitute a service, which could not be performed, unless the State lent her aid and provided such an agency as the Department of Agriculture for the purpose.

There are also the preparation of the annual reports, the editing and publishing of numerous bulletins of information, the giving of expert advice upon the scientific and practical questions that arise, the securing of capable teachers in the great school of the farmers' institute work, and the keeping posted in regard to the latest and best that is known in all lines of agriculture, which keep the Department officers constantly engaged.

I wish also to express my appreciation of the uniform courtesy and co-operation of the several Division officers, and of the clerks and employes of the Department, and for their valuable assistance, without which the work could not have been performed.

Very respectfully yours,

JOHN HAMILTON,
Secretary of Agriculture.

REPORT OF THE DEPUTY SECRETARY AND DIRECTOR OF FARMERS' INSTITUTES.

Harrisburg, Pa., December 31, 1902.

Hon. John Hamilton, *Secretary of Agriculture:*

Sir: I have the honor to present herewith the report of the progress of Farmers' Institutes, for the year ending June 1, 1902. Tables accompanying this report will show the number of institutes held in the different counties, the sessions into which these meetings were divided, the number of lecturers, local speakers and assayists who were present, the average daily attendance, together with the total attendance at the institutes in each county.

There were held in all, 324 days of regularly scheduled institutes, divided into 782 sessions. At most of the meetings, three State speakers were present; these were joined by an army of 684 local lecturers. The attendance was all that could have been expected, the daily average being 445, and the total attendance being 144,431.

An interesting feature of this brief report is noted in the variation of attendance in the different counties. Among those having the largest daily average we find, Allegheny, 491; Armstrong, 475; Bedford, 543; Berks, 520; Bradford, 440; Bucks, 555; Butler, 426; Cambria, 490; Centre, 506; Chester, 444; Clarion, 477; Columbia, 925; Crawford, 578; Delaware, 457; Huntingdon, 511; Indiana, 527; Jefferson, 435; Juniata, 408; Lancaster, 583; Lawrence, 460; Lehigh, 463; Luzerne, 603; Lycoming, 431; Mercer, 780; Mifflin, 500; Montgomery, 724; Montour, 525; Northumberland, 554; Perry, 545; Snyder, 469; Somerset, 521; Tioga, 512; Venango, 516; Warren, 420; Washington, 402; Westmoreland, 537; Wyoming, 444; York, 472.

It will be seen that Columbia county had the largest daily attendance (925). In order that the public may have knowledge of this branch of the work, the complete schedule is hereto appended:

PENNSYLVANIA FARMERS' INSTITUTES. SEASON OF 1901-1902.

County.	Place.	Date.	Days of institute.	Number of sessions.	Speakers present. State.	Speakers present. Local.	Attendance. Average.	Attendance. Total.
Adams,	Fairfield,	Jan. 9-10,	2	5	4	1		707
	Biglerville,	Jan. 11,	1	2	4	1		109
	East Berlin,	Jan. 13-14,	2	5	4	1	368	1,035
Allegheny,	Deer Creek,	Dec. 2-3,	2	5	3	2		740
	Sharon Church,	Dec. 18-19,	2	5	4			845
	Oakdale,	Dec. 30-31,	2	5	2		491	1,360
Armstrong,	Apollo,	Jan. 30-31,	2	5	4			1,035
	Slatelick,	Jan. 31-Feb. 1,	2	4	4			938
	Elderton,	Feb. 3-4,	2	5	3		475	879
Beaver,	Darlington,	Dec. 16-7,	2	5	3			390
	Hookstown,	Dec. 20-21,	2	4	3		258	640
Bedford,	Mench,	Feb. 19-20,	2	5	4	8		1,015
	Woodbury,	Feb. 21-22,	2	5	3			971
	Salemville,	Feb. 24,	1	3	3	4	543	722
Berks,	Boyertown,	Feb. 24-25,	2	5	3	2		1,625
	Geigertown,	Feb. 26-27,	2	6	3	3		700
	Hamburg,	Feb. 28-Mar. 1,	2	5	4	2	520	796
Blair,	Juniata,	Dec. 13-14,	2	5	3	12		169
	East Freedom,	Dec. 15-16,	2	5	4	6	163	485
Bradford,	Spring Hill,	Dec. 16-17,	2	5	3	7		795
	Rome,	Dec. 18-19,	2	5	3	9		516
	East Smithfield,	Dec. 20-21,	2	5	3	24		1,355
	Granville Center,	Dec. 30-31,	2	5	3	7	440	860
Bucks,	Langhorne,	Jan. 29-30,	2	5	3			1,860
	Springtown,	Jan. 31-Feb. 1,	2	5	3			705
	Somerton,	Feb. 5-6,	2	5	3	2		1,600
	Pineville,	Feb. 7,	1	3	3		666	500

PENNSYLVANIA FARMERS' INSTITUTES—Continued.

County.	Place.	Date.	Days of institute.	Number of sessions.	Speakers present. State.	Speakers present. Local.	Attendance. Average.	Attendance. Total.
Butler,	Jefferson Center,	Dec. 4-5,	2	5	2	....	....	[illegible]
	West Sunbury,	Dec. 6-7,	2	4	2	....	....	715
	Slipperyrock,	Dec. 9-10,	2	5	3	....	[illegible]	[illegible]
Cambria,	Loretto,	Dec. 9-10,	2	5	4	5	....	[illegible]
	Scalp Level,	Dec. 11-12,	2	5	4	11	400	[illegible]
Cameron,	Emporium,	Jan. 29-30,	2	5	4	6	....	[illegible]
	Driftwood,	Jan. 31,	1	3	4	4	[illegible]	[illegible]
Carbon,	Weatherly,	Jan. 6,	1	3	3	1	....	[illegible]
	New Mahoning,	Jan. 7,	1	2	3	....	225	[illegible]
Centre,	Stormstown,	Dec. 30-31,	2	5	4	5	....	[illegible]
	Hublersburg,	Jan. 1-2,	2	5	4	4	[illegible]	[illegible]
Chester,	Oxford,	Dec. 4,	1	2	4	4	....	[illegible]
	Atglen,	Dec. 7,	1	3	3	7	....	620
	Cedarville,	Dec. 11-12,	2	6	3	5	....	[illegible]
	Westgrove,	Dec. 16,	1	2	4	1	....	215
	Byers,	Dec. 19,	1	3	3	....	444	325
Clarion,	Curllsville,	Feb. 6-7,	2	5	4	10	....	1,170
	Callensburg,	Feb. 10-11,	2	5	4	9	....	695
	Salem,	Feb. 12-13,	2	5	3	5	477	1,000
Clearfield,	Grampian,	Dec. 18-19,	2	5	5	....	....	620
	Troutville,	Dec. 19-20,	2	5	4	....	....	700
	Kerrmoor,	Dec. 20-21,	2	4	4	....	[illegible]	465
Clinton,	Flemington,	Jan. 3-4,	2	6	4	3	....	350
	McElhattan,	Jan. 6,	1	3	5	....	234	350
Columbia,	Jerseytown,	Feb. 10-11,	2	5	3	5	....	1,825
	Orangeville,	Feb. 12-13,	2	6	3	10	....	1,925
	Catawissa,	Feb. 14-15,	2	5	3	8	925	1,800

Crawford,	Conneaut Center,	Feb. 19-20,	2	5	3			1,230
	Blooming Valley,	Feb. 21-22,	2	5	3			1,605
	Cambridge Springs,	Feb. 24-25,	2	5	3			756
	Riceville,	Feb. 26-27,	2	5	3		578	1,033
Cumberland,	Oaksville,	Jan. 3-4,	2	5	5	4		359
	Dickinson,	Jan. 6-7,	2	5	3	5		596
	Hoguestown,	Jan. 8	1	3	4	5	223	360
Dauphin,	Fisherville,	Feb. 28-Mar. 1,	2	3	4			460
	Linglestown,	Mar. 3-4,	2	5	4		265	600
Delaware,	Concordville,	Dec. 2-3,	2	5	4	2		900
	Manoa,	Dec. 9-10,	2	5	3	3	457	927
Elk,	Rasselas,	Jan. 17-18,	2	4	4	5		143
	St. Mary's,	Jan. 27-28,	2	5	4	7	332	1,183
Erie,	Union City,	Feb. 26-27,	2	5	5	5		835
	Edinboro,	Feb. 28-Mar 1,	2	5	4	8		605
	West Springfield,	Mar. 3-4,	2	5	4	6	365	750
Fayette,	Uniontown,	Jan. 11,	1	3	2			354
	Point Marion,	Jan. 13-14,	2	5	3			876
	Perryopolis,	Jan. 15-16,	2	5	3		394	742
Forest,	Tionesta,	Feb. 14-15,	2	5	4	8		440
	East Hickory,	Feb. 19,	1	3	4	1	221	223
Franklin,	Orrstown,	Feb. 3-4,	2	3	3			745
	Fayetteville,	Feb. 5-6,	2	5	3			785
	Marion,	Feb. 7,	1	3	3			325
	Lemasters,	Feb. 8,	1	3	3		364	325
Fulton,	McConnellsburg,	Feb. 25-26,	2	4	2	6		434
	Needmore,	Feb. 27,	1	3	2	1	254	330
Greene,	Khedive,	Jan. 7-8,	2	5	3			650
	Newtown,	Jan. 9-10,	2	3	2		300	545
Huntingdon,	Shade Gap,	Jan. 27-28,	2	5	4	7		940
	Calvin,	Jan. 29-30,	2	5	4	25	511	1,105
Indiana,	Willet,	Dec. 2-3,	2	5	3	14		935
	Tanoma,	Dec. 4-5,	2	5	4	16		890
	Cookport,	Dec. 6-7,	2	5	4	13	527	1,335
Jefferson,	Allens Mills,	Jan. 31-Feb. 1,	2	5	4	29		1,750
	Content,	Feb. 3,	1	3	4	13		215
	Ringgold,	Mar. 6-7,	2	3	2	1	435	210
Juniata,	Richfield,	Jan. 29-30,	2	5	3	6		1,066
	Academia,	Jan. 31-Feb. 1,	2	3	3	3	468	568

PENNSYLVANIA FARMERS' INSTITUTES—Continued.

County.	Place.	Date.	Days of institute.	Number of sessions.	[illegible]	Local.	Average.	Total.
Lackawanna,	[illegible]	Dec. [illegible]	1	3	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	Dec. 10,	1	3	[illegible]			[illegible]
	Fleetville,	Dec. 11,	1	3	[illegible]	[illegible]		[illegible]
	Tompkinsville,	Dec. 12,	1	3	[illegible]	[illegible]		[illegible]
	Daleville,	Dec. 13,	1	3	[illegible]	[illegible]	[illegible]	[illegible]
Lancaster,	Quarryville,	Dec. [illegible]	2	5	[illegible]	[illegible]		[illegible]
	New Holland,	Dec. [illegible]	2	4	[illegible]	[illegible]		[illegible]
	Gap,	Dec. 17-18,	2	5	[illegible]	[illegible]		[illegible]
	Lampeter,	Mar. 3-4,	2	5	[illegible]	[illegible]		[illegible]
	Black Barren Springs,	Sept. [illegible]	2	5	[illegible]			[illegible]
Lawrence,	Princeton,	Dec. 11-12,	2	5	[illegible]			[illegible]
	Mountair,	Dec. 13-14,	2	5	[illegible]			[illegible]
	Volant,	Feb. 27-28,	2	5	[illegible]	4	[illegible]	[illegible]
Lebanon,	Jonestown,	Feb. 24,	1	3	[illegible]			[illegible]
	Schaefferstown,	Feb. 25,	1	3	4			[illegible]
	Richland,	Feb. 26,	1	2	4			[illegible]
	Campbelltown,	Feb. 27,	1	3	4		[illegible]	[illegible]
Lehigh,	Fogelsville,	Feb. 12-13,	2	5	4	1		1,625
	Hosensack,	Feb. 14-15,	2	5	4	4		[illegible]
	East Texas,	Mar. 3-4,	2	5	3	3	[illegible]	450
Luzerne,	Carverton,	Jan. 1,	1	3	3			300
	Lehman,	Jan. 2,	1	3	3	1		685
	Conyngham,	Jan. 3-4,	2	5	3	1		1,430
	Nescopeck,	Dec. 28,	1	3	2		603	600
Lycoming,	Warrensville,	Dec. 2,	1	3	3	1		485
	Glade Run,	Dec. 3,	1	3	3			131
	Alliance Hall,	Dec. 4,	1	3	3			224
	Hughesville,	Dec. 5-6,	2	5	3	7	431	1,315
McKean,	Port Allegany,	Jan. 13-14,	2	5	4	12		505
	Farmers' Valley,	Jan. 15-16,	2	5	4		254	530

Mercer,	North Vernon,	Feb. 10-11,	2	5	4			1,200
	Leesburg,	Feb. 12-13,	2	5	4			1,560
	North Liberty,	Feb. 14-15,	2	5	4			1,800
	Jackson Centre,	Feb. 19,	1	3	2	4	780	900
Mifflin,	Belleville,	Jan. 15-16,	2	5	3	3		850
	McVeytown,	Jan. 17,	1	3	2	4	500	650
Monroe,	Kresgeville,	Jan. 8-9,	2	5	3	2		325
	Sciota,	Jan. 10-11,	2	5	4	1	182	405
Montgomery,	Worcester,	Dec. 30-31,	2	5	4	3		695
	Pennsburg,	Feb. 3-4,	2	5	4	3		1,300
	Souderton,	Feb. 10-11,	2	5	3		724	1,350
Montour,	Washingtonville,	Feb. 5-6,	2	5	3	2		1,050
	Oakgrove,	Feb. 7,	1	3	3	7	525	525
Northampton,	Moorestown,	Jan. 13-14,	2	5	3	2		1,002
	Farmersville,	Jan. 15-16,	2	5	3	2		625
	Lower Saucon,	Jan. 17-18,	2	5	4	2	391	722
Northumberland,	Turbotville,	Jan. 31-Feb. 1,	2	5	4	5		1,250
	Elysburg,	Feb. 3-4,	2	5	3	3	544	925
Perry,	Landisburg,	Jan. 17-18,	2	5	4	11		1,200
	Millerstown,	Jan. 27-28,	2	5	2	11		982
	Mitchells Gap,	Aug.,					545	3,000
Philadelphia,	Horticultural Hall,	Feb. 19,	1	2	6	6		175
	Bustleton,	Feb. 20-21,	2	4	3	9	275	650
Pike,	Milford,	Jan. 27,	1	2	3			80
	Dingmans Ferry,	Jan. 28,	1	2	3		50	40
Potter,	Genesee,	(Abandoned, small-pox),						
	Coudersport,	Jan. 10-11,	2		3	17	375	750
Schuylkill,	Andreas,	Feb. 19,	1	2	1	1		285
	Orwigsburg,	Feb. 19-20,	2	4	3	2		385
	Pinegrove,	Feb. 20-21,	2	4	3	3		295
	Hegins,	Feb. 22,	1	2	3	2	204	200
Snyder,	Mt. Pleasant Mills,	Jan. 10-11,	2	5	4	6		1,050
	Beavertown,	Jan. 13-14,	2	5	3	5	469	875
Somerset,	Somerset,	Feb. 10-11,	2		3	2		1,175
	Berlin,	Feb. 12-13,	2		3	1		954
	Salisbury,	Feb. 14,	1		3		521	475
Sullivan,	Colley,	Dec. 9-10,	2	5	4	22	223	446
Susquehanna,	Clifford,	Dec. 2,	1	3	4			330
	Harford,	Dec. 3,	1	3	4	2		205
	Hopbottom,	Dec. 4,	1	3	4			177
	Montrose,	Dec. 5,	1	3	4	3		485
	Franklin,	Dec. 6,	1	3	4			255
	Rush,	Dec. 7,	1	3	3	1	328	[illegible]

PENNSYLVANIA FARMERS' INSTITUTES—Continued.

County.	Place.	Date.	Days of institute.	Number of sessions.	Speakers present.		Attendance.	
					State.	Local.	[illegible]	Total.
Tioga,	Lawrence,	Jan. 1-2,	[illegible]	5	[illegible]	[illegible]	....	1,375
	Tioga,	Jan. 3-4,	2	5	[illegible]	[illegible]	....	[illegible]
	Westfield,	Jan. 6-7,	2	5	[illegible]	[illegible]	[illegible]	[illegible]
Union,	Buffalo Roads,	Jan. 7-8,	2	4	[illegible]	[illegible]	....	[illegible]
	Hartleton,	Jan. 9,	1	3	[illegible]	[illegible]	[illegible]	[illegible]
Venango,	Salina,	Feb. 5-6,	[illegible]	5	[illegible]	....	....	[illegible]
	Cooperstown,	Feb. 7-8,	[illegible]	5	[illegible]	....	....	[illegible]
Warren,	Youngsville,	Feb. 20-21,	[illegible]	5	[illegible]	[illegible]	....	[illegible]
	Lander,	Feb. 24-25,	2	....	[illegible]	[illegible]	[illegible]	[illegible]
Washington,	Amity,	Jan. 1-2,	[illegible]	5	[illegible]	....	....	[illegible]
	Prosperity,	Jan. 3-4,	2	5	[illegible]	....	[illegible]	715
Wayne,	Newfoundland,	Dec. 14,	1	1	[illegible]	....	....	[illegible]
	Hemlock Hollow,	Dec. 16,	1	2	[illegible]	....	....	[illegible]
	Ariel,	Dec. 17-18,	2	5	[illegible]	....	....	428
	Indian Orchard,	Dec. 19,	1	2	[illegible]	....	....	124
	Waymart,	Dec. 20,	1	3	4	....	[illegible]	290
Westmoreland,	Smithton,	Jan. 17-18,	2	5	2	....	....	1,560
	Greensburg,	Jan. 27,	1	2	3	....	....	140
	Export,	Jan. 28-29,	2	5	4	....	[illegible]	987
Wyoming,	Tunkhannock,	Dec. 11-12,	2	4	3	10	....	1,075
	Factoryville,	Dec. 13-14,	2	4	4	10	444	700
York,	Monaghan,	Dec. 20-21,	2	5	3	6	....	320
	Stewartstown,	Dec. 30-31,	2	4	3	5	....	2,434
	Dover,	Jan. 1-2,	2	5	4	4	....	523
	Hanover,	Jan. 15-16,	2	5	4	6	476	532
			324	782	628	684	445	144,431

The steady growth of the Farmers' Institutes is noted by the constantly increasing attendance. Very lively interest was manifested by the farmers and their families, who, in many instances, drove ten to fifteen miles over bad roads and through storm and snow to join with the State instructors on the programme, and kindly co-operating in the work of developing the best thought and most practical manner of conducting the various lines of farm operations.

The Ladies Session has become an established feature. At this session a lady usually occupies the chair. The entire programme is filled with topics relative to home comfort, health, social conditions, etc. The education of country children is also earnestly discussed, and properly so. No class of people in Pennsylvania realize more fully than the farmers the need of a more thorough education. The great mass of their children are not receiving this education, which, in my judgment, should largely be along the lines of what would seem to be their life's work. At all the institutes held in 1900, an almost unanimous vote was in favor of a township high school, or a centralized township school. It is most gratifying to note that the legislature has enacted laws appropriating money for township high schools, and has also passed an act providing for centralized township schools. We feel quite safe in the prediction that somewhere, not far from the farm home, the farmers' children will have access to a school having a class in agricultural chemistry, botany, animal life, insects, birds, etc., thus demonstrating and teaching their various relations to farm life.

AGRICULTURAL SOCIETIES.

In the work of collecting a list of county and local Agricultural Societies, it is deemed worthy of note to mention that more than usual interest and care has been manifested by the farmers in the preparation of various products for exhibition, which procured for the exhibitor greater space and better facilities for the display of farm products. Expert judges to pass upon the merits of all competing articles is rapidly becoming the rule. Possibly in no year within the last decade were the exhibits so full and complete and the attendance so large as that of 1902. This may be accounted for, partially, by the unprecedented prosperity which has attended most lines of farm operations the past year.

The following report shows that 1,024,250 people were in attendance. These societies own 50 one-half mile race tracks and 9 one-third mile tracks. They collected in membership fees, \$2,297.10; amount paid in premiums, \$113,347.93. The following is a detailed report:

List of County and Local Agricultural Societies, with Names and Addresses of Presidents and Secretaries and Dates for Holding Fall Exhibitions of 1902, Etc.

County	Corporate Name of Society.	Name and Address of President.	Name and Address of Secretary
	Pennsylvania State Agricultural Society,	[illegible]	J. P. Nissley, Hummelstown.
	State Horticultural Association,	[illegible], 1430 S. Penn St., Philadelphia.	Enos B. Engle, Waynesboro.
	Grangers' Picnic Exhibition Association,	R. H. Thomas, Mechanicsburg.	H. S. Mehler, Mechanicsburg.
	Mt. Gretna Agricultural, Mechanical and Industrial Exposition.	J. H. Redsecker, Lebanon,	[illegible], Hellman Dale.
	Patrons of Husbandry Exhibition,	L. Rhone, Chairman, Centre Hall	
	Pennsylvania State Dairymen's Association,		G. H. St. John, Meadville.
Adams,	Adams County Agricultural Association,	Jno. F. Bushey, Arendtsville,	A. I. Weidner, Arendtsville.
Allegheny,	Clinton Agricultural Association,	S. S. Ferguson, Clinton,	J. S. Burns, Clinton.
Armstrong,	Dayton Agricultural and Mechanical Association,	W. C. Marshall, Dayton,	E .E. Lawson, Dayton.
Armstrong,	Kittanning Fair Association,	G. W. [illegible], Kittanning,	[illegible], Kittanning.
Armstrong,	Armstrong County Fair Association,	[illegible], Kittanning,	Geo. H. Burns, Kittanning.
Beaver,	Beaver County Agricultural Society,	John H. Caler, New Brighton,	Lewis Graham, Beaver.
Beaver,	Mill Creek Valley Agricultural Association, Limited,	H. W. Nelson, Hookstown,	R. M. Swaney, Hookstown.
Bedford,	Bedford County Agricultural Society,	David W. Lee, Bedford,	Wm. I. Eicholtz, Bedford.
Berks,	Agricultural and Horticultural Association of Berks County.	James McGowan, Geiger's Mills,	Cyrus T. Fox, Reading.
Berks,	Keystone Agricultural and Horticultural Society,	Wm F. Stimmel, Kutztown,	J. B. [illegible], Kutztown.
Blair,	Blair County Agricultural Society,	A. L. Vare, Hollidaysburg,	Frank H. Fay, Hollidaysburg.
Bradford,	Bradford County Agricultural Society,	Geo. W. Kilmer, Monroeton,	Chas. M. Culver, Towanda.
Bradford,	Union Agricultural Association,	John H. Brown, Cedar Lodge,	C. D. [illegible], Canton.
Bradford,	Troy Agricultural Society,	B. A. Long, Troy,	Chas. L. Fellows, Troy.
Butler,	Butler County Agricultural Society,	W. H. H. Riddle, Butler,	W. P. Roessing, Butler.
Cambria,	Ebensburg Agricultural Society,	Thos. J. Hughes, Ebensburg,	A. J. Waters, Ebensburg.
Cambria,	Cambria County Agricultural Association,	Jacob A. Hoover, Carrolltown,	J. V. Mancher, Carrolltown.
Cambria,	Tri-County Agricultural and Driving Park Association,		J. H. Lavine, Johnstown.
Cameron,	Cameron County Agricultural Society,	F .X. Blumle, Emporium,	N. A. Ostrum, Emporium.
Carbon,	Carbon County Industrial Society,	Henry Miller, Lehighton,	Chas. E. Brinkman, Lehighton.
Centre,	Centre County Agricultural Exhibiting Company,	Ellis L. Orvis, Bellefonte,	John Blanchard, Bellefonte.
Chester,	Oxford Agricultural Society,	Wm. H. Hogg, Kirkwood,	Harry C. Thomas, Oxford .

Clarion,	Clarion County Fair Association,	George Yonkers, Clarion,	S. S. Laughlin, Clarion.
Clearfield,	Clearfield County Agricultural Society,	Peter Gearhart, Curwensville,	R. E. Shaw, Clearfield.
Clinton,	Clinton County Agricultural Society,	Joel A. Herr, Cedar Springs,	J. R. Porter, Mackeyville.
Columbia,	Columbia County Agricultural, Horticultural and Mechanical Association.	A. C. Creasy, Calvin Run,	A. N. Yost, Bloomsburg.
Crawford,	Central Crawford Agricultural Society,	Geo. L. Wade, Cambridge Springs,	Albert S. Faber, Cambridge Springs.
Cumberland,	Cumberland County Agricultural Society,	Chas. H. Mullin, Mt. Holly Springs,	W. H. McCrea, Carlisle.
Dauphin,	Middletown Fair Association,	Wm. M. Lauman, Middletown,	Wm. Shireman, Middletown.
Dauphin,	Gratz Agricultural and Horticultural Association,	A. G. Staley, Lykens,	J. W. Hoffman, Gratz.
Delaware,	Delaware County Agricultural Society,	J. Milton Lutz, Manoa,	Jos. H. Paschall, Ward.
Erie,	Wattsburg Agricultural Society,	S. D. West, Wattsburg,	John J. Rouse, Wattsburg.
Fayette,	Fayette Fair Association,	Wm. M. Thompson, Uniontown,	Wm .W. Parshall, Uniontown.
Greene,	Waynesburg Fair Association,	John T. Rogers, Waynesburg,	John S. Carter, Waynesburg.
Greene,	Greene County Agricultural and Mechanical Society,	J. L. Smith, Carmichaels,	H. G. Lincoln, Carmichaels.
Greene,	Richhill Agricultural Society,	Stephen Knight, Wind Ridge,	O. E. Burns, Wind Ridge.
Huntingdon,	Huntingdon County Agricultural Society,		W. A. Neff, Warriors Mark.
Indiana,	Indiana County Agricultural Society,	M. F. Jamison, Indiana,	David Blair, Indiana
Jefferson,	Punxsutawney Fair Association,	Ira J. Campbell, Punxsutawney,	Benj. Recon, Punxsutawney.
Juniata,	Juniata County Agricultural Society,	T. K. Beaver, Academia,	J. L. Groninger, Port Royal.
Lackawanna,	Lackawanna County Agricultural Society,	H. W. Northup, Glenburn,	Wm Streater, Chinchilla
Lackawanna,	Maitland Driving Park and Fair Association,	Dr. V. C. Decker, Nicholson,	W. C. Smith, Dalton.
Lackawanna,	North Abington and Glenburn Farmers' Club,		Isaac Ellis, Glenburn.
Lancaster,	Lancaster County Fair and Horse and Cattle Show Association.	R. P. McGrann,	Wm. J. Fordney, Lancaster.
Lancaster,	Lancaster County Agricultural Society,		Simon L. Brandt, Marietta.
Lancaster,	Lancaster County Agricultural and Horticultural Society,	H. M. Mayer, Rohrerstown,	F. R. Diffenderfer, Lancaster.
Lawrence,	Lawrence County Agricultural and Horticultural Society,	Sam'l McCreary, Neshannock Falls,	H. W. Grigsby, New Castle.
Lebanon,	Lebanon Valley Fair Association,	C. R. Lantz, Lebanon,	John K. Funck, Lebanon.
Lebanon,	Lebanon County Agricultural and Horticultural Association.	Sam'l Groh, Lickdale,	S. P. Heilman, Heilmandale.
Lehigh,	Lehigh County Agricultural Society,	Jeremiah Roth, Allentown,	Harry B. Schall, Allentown.
Luzerne,	Dallas Union Agricultural Association,	Chas. H. Hall, Wilkes-Barre,	Will Norton, Dallas .
Lycoming,	Muncy Valley Farmers' Club	E. W. Michael, Hughesville,	P. M. Newman, Hughesville.
Mercer,	Mercer County Agricultural Society,	Jos. Bentley,	Geo. H. Fowler, Stoneboro.
Mercer,	Mercer Central Agricultural Society,	T. P. Munnell, Volant,	John T. Crill, Mercer.
Mifflin,	Mifflin County Agricultural Society,	Jas. H. Sigler, Lewistown,	A. T. Hamilton, Lewistown.
Monroe,	Monroe County Agricultural Society,	J. S. Williams, Stroudsburg,	Chas. L. Rhodes, Stroudsburg.
Montour,	Montour County Agricultural Society,	C. A. Wagner, Ottawa,	W. D. Steinbach, Milton.
Northampton,	Northampton County Agricultural Society,	Peter Edelman, Hecktown,	John R. Reinheimer, Nazareth.
Northampton,	Pennsylvania State Fair Association,	J. Walter Lovatt, Bethlehem,	H. A. Growman, Bethlehem.
Northumberland,	Milton Driving Park and Fair Association,	Harry M. Chamberlain, Milton,	Edwin Paul, Milton.
Perry,	Perry County Agricultural Society,	D. H. Sheibley, Landisburg,	H. C. F. Stephens, Newport.
Philadelphia,	Pennsylvania Horticultural Society,	Jas. W. Paul, Jr., Drexel Building,	David Rust, Horticultural Hall, Phila.

List of County and Local Agricultural Societies, with Names and Addresses of Presidents and Secretaries and Dates for Holding Fall Exhibitions of 1902, Etc.—Continued.

County.	Corporate Name of Society.	Name and Address of President.	Name and Address of Secretary.
Schuylkill,	Orwigsburg Agricultural and Horticultural Society,	[illegible], Orwigsburg,	[illegible]
Somerset,	Somerset County Agricultural Society,	[illegible]	[illegible]
Sullivan,	Sullivan County Agricultural Society,	M. R. Black, Forksville,	[illegible]
Susquehanna,	Susquehanna County Agricultural Society,	F. C. Lott, Montrose,	W. A. [illegible], Montrose.
Susquehanna,	Harford Agricultural Society,	G. A. Stearns, Harford,	[illegible], Harford.
Tioga,	Cowanesque Valley Agricultural Society,	Chas. Tubbs, Osceola,	J. W. Smith, Westfield.
Tioga,	Smythe Park Association,	C. S. Ross, Mansfield,	[illegible], Mansfield.
Tioga,	Tioga County Pomona Grange,	F. E. Field, Wellsboro,	[illegible]
Venango,	Oil City Fair and Trotting Association,		I. N. Hinderliter, Oil City.
Washington,	Western Pennsylvania Agricultural Association,	John W. Hallam, Washington,	Jas. P. Edglean, Washington.
Washington,	Union Agricultural Association,	John L. McGough, Burgettstown,	[illegible], Burgettstown.
Wayne,	Wayne County Agricultural Society,	W. L. Ferguson, Seelyville,	E. W. Gammell, Bethany.
Westmoreland,	Westmoreland Agricultural Society,	M. N. Clark, Claridge,	[illegible], Greensburg.
Wyoming,	Wyoming County Agricultural Society,	D. W. Stark, Tunkhannock,	W. N. Reynolds, Tunkhannock.
York,	York County Agricultural Society,	John H. Wogan, York,	Edw. C. Chapin, York.
York,	Hanover Agricultural Society,	R. M. Wirt, Hanover,	M. O. Smith, Hanover.

Note.—Where dates, etc., are omitted, no replies to requests for same were received by this Department.

List of County and Local Agricultural Societies, with Names and Addresses of Presidents and Secretaries and Dates for Holding Fall Exhibitions of 1902, Etc.—Continued.

County.	Corporate Name of Society.	Attendance, 1901.	Race track.	Membership.		Premiums.		Held 1902.	
				No.	Fee	Paid 1901.	Offered 1902.	Place.	Date.
	Pennsylvania State Agricultural Society,	31,750	½ mile,	700		$3,375 50	$15,000 00	Lancaster,	Sept. 16-19.
	State Horticultural Association,								No fair.
	Grangers' Picnic Exhibition Association,	60,000	No,					Williams Grove,	Aug. 25-29.
	Mt. Gretna Agricultural, Mechanical and Industrial Exposition.		No,					Mt. Gretna,	
	Patrons of Husbandry Exhibition,		No,				Pay none	Grange Park, Centre Hall.	
	Pennsylvania State Dairymen's Association,								
Adams,	Adams County Agricultural Association,								No fair.
Allegheny,	Clinton Agricultural Association,		½ mile,						No fair.
Armstrong,	Dayton Agricultural and Horticultural Association.		1-3 mile,						
Armstrong,	Armstrong County Fair Association,	25,000	½ mile,	54			6,000 00	Kittanning,	Aug. 19-22.
Armstrong,	Kittanning Fair Association,		½ mile,						
Beaver,	Beaver County Agricultural Society,		No,	200	$200 00	No fair,			Not decided.
Beaver,	Mill Creek Valley Agricultural Association, Limited.		1-3 mile,	16		2,000 00		Hookstown,	Aug. 26-28.
Bedford,	Bedford County Agricultural Society,	10,000	½ mile,	287		350 00		Bedford,	Oct. 7-9.
Berks,	Agricultural and Horticultural Association of Berks County.		½ mile,						
Berks,	Keystone Agricultural and Horticultural Society.	15,000	1-3 mile,			1,200 00	1,500 00	Kutztown,	Sept. 30-Oct. 3.
Blair,	Blair County Agricultural Society,	10,000	½ mile,	50	Stock co.	1,500 00	1,500 00	Hollidaysburg,	Sept. 17-19.
Bradford,	Bradford County Agricultural Society,	20,000	½ mile,	300		1,100 00	2,800 00	E. Towanda Fair Grounds.	Sept. 23-26.
Bradford,	Union Agricultural Association,		½ mile,						
Bradford,	Troy Agricultural Society,		½ mile,					Troy,	Sept. 16-19.
Butler,	Butler County Agricultural Society,								No fair.

List of County and Local Agricultural Societies, with Names and Addresses of Presidents and Secretaries and Dates for Holding Fall Exhibitions of 1902, Etc.—Continued.

County.	Corporate Name of Society.	Attendance, 1901.	Race track.	Membership. No.	Membership. Fee.	Premiums. Paid 1901.	Premiums. Offered 1902.	Held 1902. Place.	Held 1902. Date.
Cambria,	Ebensburg Agricultural Society,		½ mile,					Ebensburg,	Aug. 26-29
Cambria,	Cambria County Agricultural Association,		½ mile,	[illegible]				Carrolltown,	Sept. 2-5.
Cambria,	Tri-County Agricultural and Driving Park Association.								
Cameron,	Cameron County Agricultural Society,								
Carbon,	Carbon County Industrial Society,	[illegible]	½ mile,			1,000 00		Lehighton,	Sept. 16-19.
Centre,	Centre County Agricultural Exhibiting Company.	10,000	½ mile,	10	Stock co.	319 00		Bellefonte,	Sept. 30-Oct. 3.
Chester,	Oxford Agricultural Society,	12,000	½ mile,		Stock co.	3,000 00		Oxford	[illegible]
Clarion,	Clarion County Fair Association,		½ mile,						
Clearfield,	Clearfield County Agricultural Society,		½ mile,						
Clinton,	Clinton County Agricultural Society,		No,	[illegible]					[illegible]
Columbia,	Columbia County Agricultural, Horticultural and Mechanical Association.	50,000	½ mile,	285		4,900 00	5,500 00	Bloomsburg,	[illegible]
Crawford,	Central Crawford Agricultural Society,	9,000	1-3 mile,			900 00	1,500 00	Cambridge Springs.	Aug. 26-29.
Cumberland,	Cumberland County Agricultural Society,	20,000	½ mile,	60	$360 00	3,000 00	3,000 00	Carlisle,	Sept. 30-Oct. 3.
Dauphin,	Middletown Fair Association,	25,000	½ mile,	50		700 00	700 00	Middletown,	Sept. 9-12.
Dauphin,	Gratz Agricultural and Horticultural Association.		½ mile,						
Delaware,	Delaware County Agricultural Society,			48	24 00				
Erie,	Wattsburg Agricultural Society,	4,500	½ mile,	300		559 00	1,000 00	Wattsburg,	Sept. [illegible]
Fayette,	Fayette Fair Association,		½ mile,						
Greene,	Waynesburg Fair Association,		½ mile,						
Greene,	Greene County Agricultural and Mechanical Society.	3,000	1-3 mile,	73	73 00	694 00	732 00	Carmichaels,	Oct. 1-2.
Greene,	Richhill Agricultural Society,		1-3 mile,						
Huntingdon,	Huntingdon County Agricultural Society,								
Indiana,	Indiana County Agricultural Society,	30,000	½ mile,			3,000 00	3,500 00	Indiana,	Sept. 9-12.

Jefferson,	Punxsutawney Fair Association,		½ mile,					Punxsutawney,	Aug. 27-30.
Juniata,	Juniata County Agricultural Society,	5,000	½ mile,	107		300 00	300 00	Port Royal,	Sept. 10-12.
Lackawanna,	Lackawanna County Agricultural Society,			160	50				No fair.
Lackawanna,	Maitland Driving Park and Fair Association,	6,000	½ mile,			1,400 00	1,400 00	Wallsville,	Sept. 16-19.
Lackawanna,	North Abington and Glenburn Farmers' Club,								
Lancaster,	Lancaster County Agricultural Society,								
Lancaster,	Lancaster County Fair and Horse and Cattle Show Association.							Lancaster,	Sept. 16-19.
Lancaster,	Lancaster County Agricultural and Horticultural Society.								
Lawrence,	Lawrence County Agricultural and Horticultural Society.		½ mile,	14	3 50			New Castle,	Oct. 1-3.
Lebanon,	Lebanon Valley Fair Association,	11,000	½ mile,	500		4,143 00	4,000 00	Lebanon,	Sept. 3-5.
Lebanon,	Lebanon County Agricultural and Horticultural Association.								
Lehigh,	Lehigh County Agricultural Society,	250,000	½ mile,	882		22,000 00	20,000 00	Allentown,	Sept. 23-26.
Luzerne,	Dallas Union Agricultural Association,	20,000	½ mile,	300	25 00	1,600 00	2,650 00	Dallas,	Sept. 30-Oct. 3.
Lycoming,	Muncy Valley Farmers' Club,	12,000	½ mile,			1,850 00	1,850 00	Hughesville,	Sept. 24-26.
Mercer,	Mercer County Agricultural Society,	30,000	½ mile,	350		4,000 00	5,000 00	Stoneboro,	Sept. 30-Oct. 2.
Mercer,	Mercer Central Agricultural Society,	12,000	½ mile,			2,000 00	2,000 00	Mercer,	Sept. 23-25.
Mifflin,	Mifflin County Agricultural Society,	No fair,	No,						No fair.
Monroe,	Monroe County Agricultural Society,	9,000	½ mile,	80		2,000 00		Stroudsburg,	Sept. 2-6.
Montour,	Montour County Agricultural Society,								
Northampton,	Northampton County Agricultural Society,	60,000	½ mile,			8,000 00	8,000 00	Nazareth,	Sept. 16-19.
Northampton,	Pennsylvania State Fair Association,	50,000	½ mile,			13,576 00	15,000 00	Bethlehem,	Sept. 9-12.
Northumberland,	Milton Driving Park and Fair Association,	25,000	½ mile,			3,000 00	3,000 00	Milton,	Sept. 30-Oct. 3.
Perry,	Perry County Agricultural Society,	8,000	½ mile,	250		*1,350 00	†1,800 00	Newport,	Sept. 16-19.
Philadelphia,	Pennsylvania Horticultural Society,	3,500		850		1,950 00	2,400 00	Horticultural Hall, Philadelphia.	Nov. 11-15.
Schuylkill,	Orwigsburg Agricultural and Horticultural Society.	8,000	½ mile,	35		1,500 00	Not decided.	Orwigsburg,	Aug. 26-29.
Somerset,	Somerset County Agricultural Society,		No,						No fair.
Sullivan,	Sullivan County Agricultural Society,	2,500	1-3 mile,	60	15 00	211 00	700 00	Forksville,	Oct. 1-3.
Susquehanna,	Susquehanna County Agricultural Society,	5,000	No,	50		1,000 00	1,000 00	Montrose,	Sept. 16-17.
Susquehanna,	Harford Agricultural Society,	5,000	No,			950 00	1,150 00	Harford,	Sept. 24-25.
Tioga,	Cowanesque Valley Agricultural Society,	6,000	½ mile,	30	50	1,000 00	2,000 00	Westfield,	Sept. 9-12.
Tioga,	Smythe Park Association,	40,000	½ mile,		Stock co.	1,382 33	3,500 00	Mansfield,	Sept. 23-26.
Tioga,	Tioga County Pomona Grange,		½ mile,	75					No fair.
Venango,	Oil City Fair and Trotting Association,								
Washington,	Western Pennsylvania Agricultural Association,		½ mile,						No fair.
Washington,	Union Agricultural Association,	10,000	1-3 mile,	2,000	2,000 00	3,163 80	4,000 00	Burgettstown,	Sept. 30-Oct. 2.
Wayne,	Wayne County Agricultural Society,	8,000	½ mile,				1,400 00	Honesdale,	Sept. 23-26.

List of County and Local Agricultural Societies, with Names and Addresses of Presidents and Secretaries and Dates for Holding Fall Exhibitions of 1902, Etc.—Continued.

County.	Corporate Name of Society.	Attendance, '01.	Race track.	Membership. No.	Membership. Fee.	Premiums. Paid 1901.	Premiums. Offered 1902.	Held 1902 Place.	Held 1902 Date.
Westmoreland,	Westmoreland Agricultural Society, ...	12,000	½ mile,..	81	‡25 00	1,200 00	Not decided.	Youngwood, ...	Sept. 16-19.
Wyoming, ..	Wyoming County Agricultural Society, ...	[illegible]	½ mile,..	[illegible]	[illegible]	[illegible]	....	[illegible]	[illegible]
York, ...	York County Agricultural Society, ...	48,000	½ mile,..	198	....	4,674 30	6,800 00	York, ...	Oct. 6-10.
York, ...	Hanover Agricultural Society, ...	18,000	½ mile,..	100	100 00	1,500 00	2,000 00	Hanover, ...	Sept. 16-19.

Note.—Where dates, etc., are omitted, no replies to requests for same were received by this Department.
*Including races.
†Including race purses.
‡Per share.

CROP REPORTS.

Our very efficient corps of crop reporters have performed a great service to agriculture by their prompt report of crop conditions and local prices. From such reliable reports we learn that prices received for everything raised upon the farm found a more ready market and sold at a higher price than in many years. A few striking examples are herein cited in the following average prices received in the home market for the various articles named, in the past four years:

	1899.	1900.	1901.	1902.
Wheat,	$0 68	$0 73	$0 71	$0 76
Corn,	42	48	58	62
Oats,	26	32	41	44
Potatoes,	42	53	75	54
Hay, clover,	8 29	11 20	10 81	11 33
Hay, timothy,	10 69	13 85	13 30	14 25
Butter,	20	22	22	24
Ewes,	3 72	3 61	3 48	3 50
Lambs,	3 22	3 26	3 11	2 75
Horses,	78 49	87 61	98 00	111 88
Cows,	39 13	33 08	32 00	33 22
Chickens, live per pound,	08	08	08	10
Chickens, dressed,	11	12	12	13
Labor, per day, without board,	1 11	1 15	1 23	1 25
Labor, per month, without board,	20 07	20 55	22 00	....
Farm land, improved, acre,	....	58 00	60 00	55 00
Farm land, average, acre,	....	38 00	38 00	34 00

Pennsylvania has reason to be proud of the work accomplished by the means of Farmers' Institutes, which reach out into every line of farm operations and are the harbingers of good will and encouragement to thousands of farmers who are struggling with obstacles and difficulties, which, in many cases, if left unaided would end in discouragement and financial loss. We most earnestly entreat of the legislature, soon to assemble, for a more liberal appropriation, in order that this Division of the Department of Agriculture may be more efficiently equipped, that the present and coming farmer will inculcate such knowledge as will enable him to so develop the natural resources of his farm as to make it more productive year by year, adding strength to the State, a greater variety and more healthful foods for the consumer, and broader knowledge, which brings its own reward, to those who attain thereto.

Respectfully submitted,

A. L. MARTIN,

Deputy Secretary and Director of Farmers' Institutes.

REPORT OF THE DAIRY AND FOOD COMMISSIONER.

Harrisburg, Pa., December 31, 1902.

Hon. John Hamilton, *Secretary of Agriculture :*

My Dear Sir: I have the honor to make the following report of the work of the Dairy and Food Division, of the Department of Agriculture, from January 1, to December 31, 1902.

We have had in employment the usual number of agents, chemists and attorneys during this period. There has been collected by our agents, analyzed by the chemists and reported to this Division, 2,052 samples of the several food products, which are upon the markets of this State. Of this number, 1,122 were found to be true to name, or properly labelled, and 930 samples were found to be adulterated, preserved, or not properly labelled. Under the oleomargarine act there were issued 310 licenses, and we have received and paid into the State Treasury $23,927.05 for the same. In the enforcement of this act, we have had collected and analyzed 506 samples. Of this number, 183 were found to be pure butter, 41 renovated butter and 282 were found to be oleomargarine. We have prosecuted under this act 252 cases; of this number, there were terminated 57 cases, and there are still pending 195 cases. There were terminated under this act 57 cases, which were commenced previous to January 1, 1902. In the enforcement of this act we have collected and paid into the State Treasury $8,463.93 in fines and costs. There is still in the hands of the sheriffs of the several counties of the State, a large amount of fines, which have not as yet been paid in.

We have succeeded under Section 9 of the oleomargarine act, in gaining before the courts of the State, two injunctions in Philadelphia county and one in Crawford county, restraining violators from further violation of the oleomargarine act. In our report for the year 1901, we referred to the difficulty of the enforcement of the oleomargarine law in certain sections of the State, of the ignoring of a large number of bills by the grand jury of Allegheny county, and of the costs being placed upon James Terry, agent of this Division, and of the appeal to the Superior Court for the purpose of

having decided, the right of a grand jury to place costs upon a public officer, who has acted only in the performance of his duty under the law. The decision of the Superior Court, which was handed down in July, 1902, sustained the action of the grand jury.

The enactment of a National anti-color oleomargarine law, which came into force July 1, 1902, has been of great assistance to the Division in its efforts to enforce the State laws.

RENOVATED BUTTER ACT.

Under this act, we have issued two licenses, and have received and paid into the State Treasury $766.07 for the same. We have collected and analyzed 41 samples; of this number 34 were cases for prosecution. There were terminated 12 cases and there are still pending 22. There were terminated during the present year 3 cases, which were commenced previous to January 1, 1902. We have collected and paid into the State Treasury under this act, $578.58 in fines and costs.

MILK ACT.

Under this act, we have collected and analyzed 259 samples of milk and cream. Of this number, 186 were found to be pure, 45 adulterated, 27 were found to contain a preservative and one contained a coloring matter. As all adulterated samples were prosecuted under the Pure Food Law, we have prosecuted under the Milk Law, only the preserved and colored cases. Seven cases, which were commenced previous to January 1, 1902, have been terminated under this period. We have collected and paid into the State Treasury, under this act, $1,177.24 in fines and costs.

CHEESE ACT.

Under this act, we have collected and analyzed 11 samples. Of this number, 5 were found to be up to standard and 6 were found to be below standard. We have prosecuted 3 cases, which have been terminated. We have collected and paid into the State Treasury, under this act, $169.50 in fines and costs.

PURE FOOD ACT.

Under this act, we have collected and analyzed 1,181 samples. Of this number, 701 were found to be pure, or properly labelled, 230 adulterated, or not properly labelled, 239 contained a preservative and 11 coloring matter. We have prosecuted 346 cases. Of this number, 111 were terminated and 235 are pending. Forty-one cases, which were commenced previous to January, 1902, have been terminated during this period. We have collected and paid into the State Treasury, under this act, $8,082.20 in fines and costs.

LARD ACT.

Under this act, we have collected and analyzed 27 samples. Of this number, 10 were found to be pure and 17 were compound. We have prosecuted 10 cases. Of this number, 6 were terminated and 4 are still pending. One case, which was commenced previous to January 1, 1902, was terminated during this period. We have collected and paid into the State Treasury, under this act, $23.00 in fines and costs.

VINEGAR ACT.

Under this act, we have collected and had analyzed 68 samples. Of this number, 37 were found to be up to standard, 24 were below standard and 7 contained a coloring matter. We have prosecuted 25 cases. Of this number, 11 are terminated and 14 are still pending. We have collected and paid into the State Treasury, under this act, $447.42 in fines and costs.

I respectfully call your attention to the large number of samples, which were found by analysis to contain a preservative. This condition existed to a certain extent during former years, and, while prosecutions were brought upon cases which were found to contain a certain preservative, we have hesitated in bringing cases against such as contain salts-of-copper as a coloring matter, and those containing boracic acid and other preservatives of like character. But owing to the decision of the Supreme Court of the State upon certain sections of the Pure Food Act of 1895, in regard to the use of food preservatives, a copy of which I have attached to this report, we have successfully prosecuted a large number of cases, which has had such a beneficial effect, that, at the present time, parties detected selling foods containing injurious preservatives in the majority of these cases brought, have come forward and voluntarily paid their fines and costs to the magistrates, or in court. This was done especially by defendants who had been prosecuted for using boracic acid and sulphites in meats. They were defended by the large packing houses of the West, upon whom, I am reliably informed, our attitude in regard to preservatives has been the cause of having established separate departments for the special purpose of the preparation of meats for Pennsylvania markets, in which no preservatives are permitted to be used. This will be of great benefit to the farmer and meat producers of our State.

While we were somewhat discouraged in our first efforts in the enforcement of the law, as regards the use of boracic acid in food products, the outlook at the present time, is very encouraging, and we now feel that we will be able in a very short time to drive from the markets of the State, all foods which contain injurious preservatives.

To more fully explain the workings of this Division, I have attached to this report the following tables:

Table No. 1. Giving the number and showing the condition as to the purity of the samples collected by the agents, analyzed by the chemists and reported to the Division during the year. It must be remembered, that agents are instructed to omit from their samples such goods as previous analysis has shown to be pure.

Table No. 2. Giving the number of samples taken under the act, giving the number that were found to be pure, or up to standard, or properly labelled, those found not pure, or adulterated, or preserved, or colored, or not up to standard; also giving the number of samples collected and analyzed in total.

Table No. 3. Giving the suits and prosecutions which were commenced, the number which have been terminated and the number still pending on appeal or *certiorari;* also giving the number of cases, which were commenced previous to and terminated during this period.

Very respectfully,

JESSE K. COPE,

Dairy and Food Commissioner.

DEPARTMENT OF AGRICULTURE.

Harrisburg, Pa., March 5, 1902.

My Dear Sir: The Supreme Court of Pennsylvania has just handed down a decision affecting the use of preservatives in food on sale in this State. Inasmuch as the subject is one that directly concerns all manufacturers of and dealers in food products, the Department has had the entire decision printed for distribution.

JESSE K. COPE,

Dairy and Food Commissioner.

IN THE SUPREME COURT OF PENNSYLVANIA.

COMMONWEALTH vs. JOHN W. KEVIN. No. 355. JANUARY TERM, 1901.

APPEAL BY THE DEFENDANT FROM THE JUDGMENT OF THE SUPERIOR COURT OF PENNSYLVANIA.

FILED MARCH 3, 1902.
MESTREZAT, J.

The defendant, who is engaged in the grocery business in the city of Philadelphia, was tried and convicted in the court of quarter sessions of Philadelphia county on an indictment charging him with having sold "one pint of raspberry syrup, the said raspberry syrup then and there contained an added substance and ingredient, to wit: Salicylic acid, which is poisonous and injurious to health." The indictment was found under the act of June 26, 1895, P. L. 317, entitled "An act to provide against the adulteration of food and providing for the enforcement thereof," and commonly known as the Pure Food Law.

The first section prohibits the manufacture or sale of adulterated food, the second section defines the term "food" as used in the act, and the third section provides *inter alia* that "an article shall be deemed to be adulterated within the meaning of this act: (a) in case of food * * * (7) if it contains any added substance or ingredient which is poisonous or injurious to health." The defendant was indicted for a violation of the seventh clause of the third section of the act.

On the trial of the case, it was shown that the defendant had sold a bottle of raspberry syrup, and it was admitted by him that it contained salicylic acid. It appeared from the evidence that the acid was a substance foreign to raspberry syrup. Expert testimony was introduced by the Commonwealth and the defense to prove what salicylic acid is, and whether it is poisonous and injurious to health.

The Commonwealth's expert made an analysis of the syrup and testified that the acid was injurious to health; that it was dangerous because it was apt to produce disease; that the words "poisonous" and "injurious to health" were almost synonymous in cases where the poison is not always fatal; that if continually used, the acid is injurious to health in any quantity, but if not so used, its injuriousness would depend upon the person taking it.

The defendant's expert testified that salicylic acid would not be classed in the group of poisons; that whether or not it is poisonous or injurious depends upon the amount taken and how it is used, which applies to arsenic or any other poisons; that if the acid was taken in a harmful amount, it would affect injuriously the digestion, the kidneys and the heart; that all poisons must be administered medicinally and that witness had known of salicylic acid being administered beneficially in medicinal doses; that the acid is a substance foreign to raspberry syrup.

The trial court submitted the case to the jury and charged that the only question to be determined by them was whether or not salicylic acid was poisonous or injurious to health; that if it was it was the duty of the jury to convict. A verdict of "guilty" was returned by the jury, and the defendant, having been sentenced, appealed to the Supreme Court, which, by a divided court, affirmed the judgment of the trial court. He thereupon appealed to this court.

The determination of the several assignments of error involves a consideration of clause seven of section three of the act of June 26, 1895, under which the indictment was found. The learned trial judge held that the clause prohibited the addition to a food product of any foreign substance poisonous or injurious to health, regardless of the quantity used or whether or not the quantity of the substance used was sufficient to make the adulterated article poisonous or injurious to health. In other words, it is not the quantity but the nature of the substance added which the act prohibits.

The court held that if the foreign substance added to an article of food is poisonous or injurious in any quantity, the statute declares it to be an adulteration. The case was tried upon this construction of the act, and the rulings of the trial court, assigned for error in the Superior Court and on this appeal, are based upon that interpretation of the statute.

The learned counsel for the defendant contend that the act is not violated unless the quantity of the foreign substance is sufficient to make the compound poisonous or injurious to health. They state their position in their fourth point for charge, which is as follows: "The defendant in this case is indicted for selling one bottle of syrup, and if the jury should find from the evidence that the single bottle actually sold did not contain salicylic acid in sufficient quantities to be poisonous or injurious to health, then your verdict must be for the defendant."

We are not prepared to adopt this construction of the clause of the section under consideration. The purpose of the statute was to prevent the adulteration of food; the term "food" including all articles used for food or drink by man.

The act clearly defines what shall be deemed an adulterated article within the meaning of its terms. The third section is subdivided into seven clauses, each defining or designating an article or compound that shall be considered as adulterated. Food is adulterated under this section: (1) If any substance or substances have been mixed with it so as to lower or depreciate or injuriously affect its quality, strength or purity. (2) If any inferior or cheaper substances have been substituted wholly or in part for it. (3) If any valuable or necessary constituent or ingredient has been wholly or in part abstracted from it. (4) If it is an imitation of or sold under the name of another article. (5) If it consists wholly or in part of a diseased, decomposed, putrid, infected, tainted or rotten animal or vegetable substance or article, whether manufactured or not, or in case of milk if it is the product of a diseased animal. (6) If it is colored, coated, polished or powered, whereby damage or inferiority is concealed, or if by any means it is made to appear better or of greater value than it really is. (7) If it contains an added substance or ingredient which is poisonous or injurious to health.

Such are the articles which are prohibited from being manufactured or sold as food in this Commonwealth. The object of the statute is to protect the public health by securing pure food and to prevent fraud and deception in the manufacture and sale of adulterated articles of food.

The purpose of the legislature in the passage of this act is most commendable, and the statute should receive a construction by the courts that will fully and effectively accomplish the object of its enactment.

It will be observed that the third section is not directed against the manufacture or sale of adulterated food, but declared what shall be deemed and taken to be an adulteration of food. Each of the several clauses is couched in explicit and unambiguous terms. The language of the clause under which this indictment was framed is plain and admits of but one meaning. It is therefore not necessary to resort to technical rules of construction in aid of its interpretation.

"Whatever may have been the legislative thought," says Thompson, J., in Bradbury vs. Wagenhorst, 54 Pa. 182, "no ambiguity exists in what they said, and when the words of the statute are plainly expressive of an intent, the interpretation must be in accordance therewith."

It is not a poisonous or injurious compound resulting from the addition of a foreign ingredient that the seventh clause declares to be an adulterated article. If it were, the position of the defendant would be correct and, under the testimony in the case, he would have been entitled to an acquittal.

The evidence introduced on the trial and admitted by the court, however, was to show that the foreign substance added to the food product was poisonous and injurious to health. That is clearly what the clause declares shall constitute an adulteration. Its language is: "If it (the adulterated food) contains any added substance or ingredient which is poisonous or injurious to health." The terms of the clause, therefore, declare against a compound that if formed by the addition of a poisonous or injurious ingredient and not against a compound that is poisonous or injurious to health.

This interpretation is supported by the plain and explicit language of the clause as well as by the manifest purpose of the Legislature in its enactment. An article resulting from the addition of a poisonous substance, the Legislature believed would be unhealthy, and, hence, its manufacture and sale is forbidden by the first section of the act. The guilt of the defendant, therefore, does not depend upon the nature or character of the compound resulting from the addition of the salicylic acid to the fruit syrup, but was to be determined solely upon the poisonous or injurious qualities of the acid, which was the ingredient added to the food.

The seventh clause of the act, as construed, does not offend against any provisions of the Constitution of the Commonwealth. It does not prevent the admixture of pure articles as a food, nor prohibit the addition of a healthful ingredient as a fruit preservative.

It is directed against the introduction into a food product of a substance foreign to it and of a poisonous or injurious nature. As said above, the purpose of the act was two-fold: To protect the public health, and to prevent fraud and deception in the manufacture and sale of adulterated food.

It is within the province of the General Assembly to determine whether the addition of a poisonous or injurious substance to a food article endangers the health of the citizens of the State, who use the compound; and if it does, then it is clearly within the police power of the State to prohibit the manufacture and sale of the adulterated article as well as to protect the public from imposition or fraud in the sale of it.

The exercise of such authority by the Legislative Department of the Government does not transcend the constitutional limits of its power. In Powell vs. Commonwealth, 114 Pa., 294, Sterrett, J., after reviewing the cases holding legislation to be constitutional on the ground that it was the lawful exercise of the police power of the State, says: "The manufacture, sale and keeping with intent to sell, may all alike be prohibited by the Legislature, if, in their judgment, the protection of the public from injury or fraud requires it. To deny the authority of the Legislature to do so, is to attack all that is vital in the police power. To refuse recognition of the power in a

given case, because in the judgment of some, the Legislature, though acting within its proper sphere, may have mistaken the public necessity for a law prohibitory in its character, is to make the individual judgment superior to that of the Legislature to which the people in their sovereign capacity have delegated the law making power."

There was ample evidence, if believed, to warrant the jury in finding that salicylic acid is poisonous and injurious to the human system. No other conclusion would have been justified by the evidence. It is equally clear that the manufacturers of the Raspberry Syrup sold by the defendant were concealing its true ingredients from the public. This is manifest from the label on the bottle on which is printed: "Warranted pure and unadulterated fruit syrup."

The testimony in this case discloses the fact that the syrup is not in "a pure and unadulterated" condition, but that it contains an ingredient foreign to its natural state.

We are of the opinion that the learned trial judge properly interpreted the act of Assembly under which this indictment was drawn, and that, therefore, his rulings on the admission of testimony and his answer to points for charge, which are complained of in the assignments of error, were correct. The judgment of the Superior Court is affirmed.

State of Pennsylvania, }
Eastern District, } ss:

I, Charles S. Greene, Prothonotary of the Supreme Court of Pennsylvania in and for the Eastern district, do hereby certify that the above and foregoing is a true copy of the opinion in the above entitled cause so full and entire as appears of record in said court.

In testimony whereof, I have hereunto set my hand and affixed the seal of said court, at Philadelphia, this fourth day of March, A. D. 1902.

(Signed.) CHARLES S. GREENE,
(Seal.) Prothonotary.

TABLE NO. 1.

Number of samples taken and analyzed from January 1, to December 31, 1902.

Allspice, pure,	1
Allspice, adulterated,	2
Almond Extract, pure,	1
Almond Extract, adulterated,	2
Apple Butter, pure,	2
Apple Butter, preserved,	1
Bacon, not preserved,	1
Baked Beans, pure,	1
Baking Powder, pure,	3
Banana Extract, adulterated,	1
Beef, not preserved,	47
Beef, preserved,	6
Beef Extract, preserved,	2
Beef Salad, pure,	1
Beer, pure,	6
Beer, adulterated,	2
Birch Beer, pure,	1
Blackberry Preserves, pure,	1
Blood Orange, colored,	2
Blood Pudding, pure,	1
Bologna, not preserved,	42
Bologna, preserved,	13
Boric Acid,	1
Brook Trout (canned), adul.,	1
Butter, pure,	183
Butter, renovated,	41
Butter, colored oleo.,	278
Butter, uncolored oleo.,	4
Candy, pure,	4
Catsup, preserved,	4
Catsup, colored,	2
Celery Salt, pure,	1
Cheese, pure,	5
Cheese, adulterated,	6
Cherry Jam, pure,	1
Cherry Kola, pure,	1
Cherry Kola, adulterated,	1
Cherry Syrup, adulterated,	1
Chicken (potted), pure,	17
Chicken Loaf, not preserved,	1
Chicken Loaf, preserved,	1
Chocolate, pure,	4
Chocolate, adulterated,	17
Chocolates, pure,	2
Chocolates, adulterated,	2
Chocolate Eggs, pure,	4
Chocolate (sweet), pure,	1
Chocolate (sweet), adulterated,	1
Chocolatina, adulterated,	1
Cider, adulterated,	1
Cinnamon, pure,	2
Cinnamon, adulterated,	1
Cloves, pure,	3
Cocoa, pure,	16
Cocoa, adulterated,	10
Cocoa Powder, pure,	2
Coffee, pure,	2
Condensed Milk, pure,	3
Condensed Milk, preserved,	2
Corn (canned), pure,	3
Corned Beef (canned), pure,	14
Corn Meal, pure,	1
Cottage Roll, preserved,	1
Cotton Seed Oil, pure,	1
Cream, pure,	29
Cream, preserved,	4
Cream of Tartar, pure,	5
Cream of Tartar, adulterated,	7
Currant Pomade, pure,	1
Devilled Crab, pure,	1
Dried Beef, not preserved,	4
Dried Beef, preserved,	1
Dried Beef (canned), not preserved,	1
Egg Flake, pure,	1
Egg Save, pure,	1
Evaporated Cream, pure,	1
Evaporated Cream, adulterated,	1
Evaporated Peaches, pure,	1
Fish (salted), pure,	1
Flour, pure,	1
Formalin, pure,	1
Frankfort Sausage, not preserved,	9
Frankfort Sausage, preserved,	12
Fruit Syrup, pure,	1
Fruit Syrup, adulterated,	2
Fruit Syrup (peach), pure,	1
Fruit Syrup (pineapple), pure,	1
Fruit Syrup (pineapple), adul.,	1
Fruit Syrup (raspberry), pure,	3
Fruit Syrup (strawberry), preserved,	2
Ginger, pure,	4
Ginger Ale, pure,	15
Ginger Ale, preserved,	2
Gooseberry Jam, pure,	1
Granulated Sugar, pure,	2
Grape Juice, pure,	1
Ham, not preserved,	29
Ham, preserved,	1
Ham (boiled), not preserved,	1
Ham (devilled), not preserved,	3
Ham (devilled), preserved,	1
Ham (minced), not preserved,	18
Ham (minced), preserved,	2
Ham (potted), not preserved,	40
Ham (potted), preserved,	5
Ham (prepared), not preserved,	1
Ham (pressed), not preserved,	2
Ham (pressed), preserved,	1
Ham Loaf, not preserved,	4
Hamburg Steak, not preserved,	22
Hamburg Steak, preserved,	21
Head Cheese, not preserved,	3
Honey, pure,	8
Honey, adulterated,	18
Infant's food, pure,	2
Jelly (currant), pure,	1
Jelly (plum), pure,	1
Jelly (raspberry), adulterated,	1
Jelly (strawberry), adulterated,	1
Lamb, not preserved,	6
Lard, pure,	10

TABLE NO 1—Continued.

Lard, compound,	17	Postum Cereal, pure,	1
Lemon Extract, pure,	5	Pudding, pure,	1
Lemon Extract, adulterated,	36	Raspberry Preserves, adul.,	2
Lime Juice, pure,	1	Roast Beef (canned), not preserved,	6
Liver Pudding, not preserved,	7	Roast Beef, not preserved,	1
Lobster (canned), not preserved,	1	Roast Fowl, not preserved,	1
Maple Sugar, pure,	1	Salmon (canned), not preserved,	1
Maple Syrup, pure,	13	Salmon (canned), preserved,	1
Maple Syrup, adulterated,	15	Salt, pure,	1
Marmalade, pure,	1	Sardines, adulterated,	1
Meat (chopped), not preserved,	8	Sarsaparilla, pure,	3
Meat (chopped), preserved,	15	Sausage (canned), not preserved,	3
Meat (fresh), not preserved,	5	Sausage (canned), preserved,	7
Melrose Pate (canned), not preserved,	2	Sausage, not preserved,	116
Milk pure,	157	Sausage, preserved,	101
Milk, adulterated,	45	Smoked Beef, not preserved,	3
Milk, preserved,	23	Smoked Beef (sliced), not preserved,	1
Milk, colored,	1	Strawberries (canned), adul.,	1
Mince Meat, pure,	2	Strawberry Extract, pure,	1
Mince Meat (condensed), pure,	5	Strawberry Extract, adulterated,	7
Molasses, pure,	4	Strawberry Jam, pure,	4
Molasses, adulterated,	10	Strawberry Preserves, pure,	1
Mustard, pure,	5	String Beans, colored and preserved,	1
Mustard, adulterated,	1	Tea, pure,	2
Mutton, not preserved,	4	Tomatoes (canned), pure,	1
Mutton, preserved,	1	Tomata Soup, pure,	1
Noodles, adulterated,	1	Tongue (pickled), pure,	1
Oat Food, pure,	2	Tongue (potted), not preserved,	2
Olive Oil, adulterated,	1	Tongue (potted), preserved,	9
Orange Extract, adulterated,	1	Turkey (canned), not preserved,	9
Ovine, colored,	1	Turkey (canned), preserved,	4
Ox-heart, preserved,	1	Vanilla Bean, pure,	2
Ox-tail soup, pure,	1	Vanilla Extract, pure,	17
Ox-tongue (potted), pure,	3	Vanilla Extract, adulterated,	49
Oysters (canned), not preserved,	8	Veal Loaf, not preserved,	14
Oysters (canned), preserved,	2	Veal Loaf, preserved,	4
Oysters (cove), not preserved,	1	Vienna Sausage, not preserved,	3
Oysters (fresh), not preserved,	1	Vienna Sausage (canned), not preserved,	3
Oysters (fresh), preserved,	3	Vienna Sausage (canned), preserved,	11
Peas (canned French), colored,	6	Vinegar, pure,	37
Peas (canned French), colored,	6	Vinegar, adulterated,	25
Pepper, pure,	26	Vinegar (distilled), colored,	6
Pepper, adulterated,	28		
Pigs Feet (pickled), not preserved,	1	Total,	2,052
Pineapple Chunks, pure,	1		
Pineapple Extract, adulterated,	4		
Pork, not preserved,	11		
Pork, preserved,	2		
Pork and Beans (canned), pure,	1		

TABLE NO. 2.

Number of samples taken and analyzed under the several laws from January 1, to December 31, 1902.

Number of cheese samples which proved to be up to standard,	5
Number of cheese samples which proved to be not up to standard,	6
Total number of cheese samples analyzed,	11

Number of lard samples which proved to be pure, ...	10
Number of lard samples which proved to be compound, ...	17
Total number of lard samples analyzed, ...	27
Number of milk and cream samples which proved to be pure,	186
Number of milk and cream samples which proved to be adulterated, ...	45
Number of milk and cream samples which proved to be preserved, ...	27
Number of milk and cream samples which proved to be colored, ...	1
Total number of milk samples analyzed, ...	259
Number of butter samples which proved to be pure, ...	183
Number of butter samples which proved to be oleomargarine, ...	282
Number of butter samples which proved to be renovated,..	41
Total number of butter samples analyzed, ...	506
Number of food samples which proved to be pure, ...	701
Number of food samples which proved to be adulterated,...	230
Number of food samples which proved to be preserved, ..	239
Number of food samples which proved to be colored, ...	11
Total number of food samples analyzed, ...	1,181
Number of vinegar samples which proved to be up to the standard and true to name, ...	37
Number of vinegar samples which proved to be not up to the standard or not true to name, ...	31
Total number of vinegar samples analyzed, ...	68
Total number of samples analyzed, ...	2,052

TABLE NO. 3.

Which gives the number of suits and prosecutions commenced, terminated and pending, from January 1, to December 31, 1902, also cases commenced previous to and terminated during the year 1902.

Cases Commenced During the Year 1902.

	Commenced.	Pending.	Terminated.
Under the cheese act of 1897,	3	....	3
Under the lard act of 1891,	10	4	6
Milk cases prosecuted under the milk act of 1901 and the pure food act of 1895,	66	18	48
Under the oleomargarine act of 1901,	252	195	57
Under the pure food act of 1895,	346	235	111
Under the renovated butter act of 1901,	34	22	12
Under the vinegar act of 1897,	25	14	11
Total,	736	448	248

Cases Commenced Previous to and Terminated During the Year 1902.

Under the lard act of 1891,	1
Under the milk act of 1901,	7
Under the oleomargarine act of 1901,	57
Under the pure food act of 1895,	41
Under the renovated butter act of 1901,	3
Total,	109

REPORT OF THE STATE VETERINARIAN.

Harrisburg, December 31, 1902.

Honorable John Hamilton, *Secretary of Agriculture:*

Sir: I have the honor to present to you herewith a report of my work as State Veterinarian for the calendar year 1902. Since it is impossible to separate the work that falls to me as State Veterinarian and as Secretary of the State Live Stock Sanitary Board, I also incorporate a review of the work of the Board. The volume of work for the year is greater than ever before. As the work of the State Live Stock Sanitary Board becomes better understood by the live stock owners of the State there is increased demand for the help that it alone can furnish. The Board is asked not only to take action and to make inspections in more instances than in the past, but it is also communicated with by persons in need of advice and assistance in respect to sanitation and the care and management of live stock. The miscellaneous correspondence that is thus growing up is becoming so large that it requires a great deal of time to attend to it and brings into prominence the question as to whether it may not soon be necessary to in some way curtail it or to enlarge the organization that is caring for it.

There has been a noticeable diminution in the prevalence of most of the infectious diseases of animals during the past year; this is particularly true in respect to tuberculosis of cattle and of anthrax and black-quarter. There has, however, been a slight increase in the prevalence of glanders, hog cholera and rabies due, in respect to glanders and hog cholera, to the importation of diseased animals from other States. There is no State inspection of horses or swine coming into Pennsylvania and practically all of the outbreaks of glanders and hog cholera that occur here are due to infected animals from other States. It is possible, however, in every instance, to gain control of and to eradicate outbreaks of these diseases, but in the case of hog cholera this may not be accomplished until considerable loss has occurred. In reference to rabies, the difficulty lies in the impossibility of establishing an effective quarantine of dogs when it is necessary to do so to control an outbreak. A bill will be introduced in the coming Legislature having for its object the correction of this defect. The text of the proposed bill is given below under the heading or rabies.

Interest in the repression of tuberculosis of cattle constantly increases and the herd owners are more than ever determined to have their live stock free from this disease. The result has been that the Board has been called upon to make nearly four times as many inspections as it is possible to make with the funds that are available for this purpose. It has thus been possible to make inspections of the worst infected herds and in this way to clean up many of the most dangerous distributing centers of the disease.

During the summer, investigations were made of the disease of cattle that has prevailed for several years among cattle pasturing in the wild, mountainous sections of the State. This disease has sometimes been called "mountain disease," and it was generally supposed by the farmers of the regions in which it occurred to be due to poisoning by some unidentified plant. As a result of investigations conducted with the assistance of Dr. S. H. Gilliland, it has been proven to be identical with the so called "rinderseuche" of Germany and with *hæmorrhagic septicæmia*, that has been recognized among cattle in Minnesota and Wisconsin. This very important discovery removes a cloud of doubt as to the cause of the loss of thousands of cattle. There are sections of the State formerly used extensively for pasturing cattle that for many years have been abandoned for this purpose, entirely on account of the prevalence of this heretofore unidentified disease. The means that it is necessary to take to control this malady are stated below.

Dr. M. P. Ravenel has continued in charge of the laboratory of the Board and has supervised the production of all of the tuberculin, mallein and anthrax vaccine used by the State Live Stock Sanitary Board. The quantities of these materials used are gradually increasing as their value in the diagnosis or prevention of disease is becoming better known. By sending them out to veterinarians free of charge their use is encouraged, to the great sanitary advantage of the Commonwealth. It is doubtful if an equal amount of good could be done by an expenditure several times as great in other directions.

The recognition of the existence of an infectious disease must be the first step preliminary to its eradication. By assisting in the early diagnosis of infectious diseases, the laboratory of the Board renders most important assistance. The laboratory is being freely used by the veterinarians of the State, who send to it specimens for opinion and diagnosis. Heads of animals that have died of a disease supposed to be rabies are sent to the laboratory in large numbers. By the use of the new method of rapid diagnosis, that has received its chief development in this country in the laboratory of the State Live Stock Sanitary Board, and the Pepper Clinical Laboratory at the hands of Dr. M. P. Ravenel and Dr. D. J. McCarthy, it is now possible to determine, with a high degree of accuracy, whether an

animal was afflicted with rabies or not. By means of this information it is possible to prevent much disease and loss of life and property. When a person is bitten by a dog that is possibly afflicted with rabies, it is of the utmost importance to that person that a diagnosis of the disease afflicting the dog shall be made promptly and accurately. If the dog was afflicted with rabies it is important that this shall be known so that the person that was bitten may adopt any precaution or treatment that may protect him from rabies. On the other hand, if the dog was not afflicted with rabies much discomfort and terror are avoided by early knowledge of this fact.

An important development during the year has been made in connection with the study of the immunization of cattle against tuberculosis. A paper on this subject was presented to the Pathological Society of Philadelphia, on November 13, 1902, by Dr. S. H. Gilliland, Assistant Bacteriologist of the State Live Stock Sanitary Board, and myself. The text of the paper will be found below. It may be observed here that it has been possible in these experiments to immunize cattle against tuberculosis. The method is based upon a principle similar to that controlling the immunization of cattle against anthrax. It is necessary to make further experiments to develop this system before it can be applied practically on farms. To do this a large experiment should be conducted under natural farm conditions; a herd of tubercular cows should be established and cared for as cattle are usually cared for on farms. The calves from such cows as they grow up should be vaccinated, with a view to endeavoring to protect them against tuberculosis. A number of healthy cattle should be added to such a tubercular herd, part of these should be vaccinated and the rest allowed to remain without vaccination, with a view to measuring and determining the value of protection afforded by vaccination under such conditions. It is also important that the shortest and simplest method of vaccination shall be determined, to the end that the system may be rendered as economical as possible. Furthermore, it is important to know how long the immunity that is thus conferred will continue. It is hoped that the coming Legislature may see the importance of developing this system of protection against a most insidious enemy of cattle and will furnish the means for renting and using a farm as an experiment station for the thorough testing and development of this discovery.

Nearly 60,000 doses of tuberculin have been made during the year, and this, together with the mallein and anthrax vaccine that have been furnished, have value equivalent to the entire cost of running the laboratory for the year, so that the special work of diagnosis, research and investigations that have been so fruitful for the past twelve months have been conducted at no cost to the State. That is, the laboratory and equipment by the use of which this work was done

earned enough money by the production of the biological products above enumerated to pay their cost of maintenance. Of course, none of these products were sold, but if they had not been produced in the laboratory it would have been necessary for the State to pay for them as much as the laboratory cost.

The comparative study of tubercle bacilli from human and bovine sources has been continued and the latest report upon this subject by Dr. Mazÿck P. Ravenel will be found below. It is believed that the investigations upon which this report is based have been conducted for a longer time and are more comprehensive than similar investigations made in any other part of the world. As the work has been done with the utmost care there is reason to have confidence in the conclusions that are stated.

Tuberculosis.—This is still the most widespread and dangerous disease among cattle in Pennsylvania. It is estimated that the losses from this disease amount to from $2,000,000.00 to $3,000,000.00 a year. This total is large, but it is believed to be a conservative estimate and upon analysis it will appear that it is by no means improbable. There are in the State about 225,000 farms and an average loss of $10 a farm would make a total of $2,250,000.00. If the average value of a dairy cow is $40, it will be seen that the loss of such a cow is equivalent to an average loss of $10 a farm for four farms; but it is not uncommon for ten cows to be lost as a result of tuberculosis; this means a total loss of $400, or an average loss of $10 a farm for forty farms. In one herd this year, the losses from tuberculosis amounted to $5,000, which is equivalent to a loss of $10 a farm for 500 farms. Undoubtedly, the losses from tuberculosis are now much smaller than they were a few years ago, and the disease is believed to be practically eradicated from many parts of the State; the parts where the herd owners themselves have taken the most active interest in repressing this scourge. But the losses are still very great and the disease is still often spread from herd to herd through the sale of tubercular cattle. The distribution of disease that formerly resulted from this cause has been checked in so far as cattle from outside of Pennsylvania are concerned. It is required that these, if intended for the dairy or for breeding purposes, shall be inspected before they are sold. The effect of this law is most beneficial and I reproduce here an analysis of its results based upon a most liberal estimate as to the cost of its operation and a most conservative estimate of its value to live stock owners. The quotation is taken from my annual report for the year 1900.

"The increased cost of inspected cows is equivalent to the cost of the inspection. This averages about fifty cents per head. In order that all possible collateral expenses may be surely covered, the extreme figure of $1.00 per head may be taken as the basis for this

calculation. On 15,000 cows this means $15,000.00 expense or cost of inspection. Now, what is the gain? Since two and one-half per cent. of the cows examined are tubercular and are prevented from entering farmers' herds, 375 cows are thus directly excluded. At the reasonable average of $40 per head this means that $15,000.00 worth of tubercular cows are denied sale in Pennsylvania. That is, the purchasers of out of State cows pay $15,000.00 for the inspection, but save $15,000.00 that they would otherwise expend for tubercular cows. But this is not the only saving. From two to three times as many tubercular cows would be brought into Pennsylvania and sold, were they not inspected, so that the direct saving may be safely estimated at $30,000.00. Moreover, many of these tubercular cows would spread infection and some of them would start disease that would undoubtedly infect whole herds. (As one of many examples the Piollet herd was thus infected by a cow from New Jersey and 156 cattle became tubercular involving a loss of more than $6,000.00 on this single herd.) If each cow should infect an average of but one animal the loss would be doubled and would reach $60,000.00 per year. I believe that this estimate is most conservative and that the money spent in testing cows from other States is the means of saving, to cow owners, at the very lowest, four times as much in direct loss from tuberculosis."

Several brilliant illustrations of the value of the inspection of cattle from outside of the State have been afforded during the past year. As an instance, in two car loads of cows from Virginia it was found that one-half were victims of rather well marked and advanced tuberculosis. Notwithstanding this fact, these cows were offered for sale and would have been sold in Chester county if it had not been for the required inspection. As it was, they were returned to Virginia. Perhaps one of the most beneficial features of the inspection law is its effect in causing cattle dealers to exercise great care in selection of cows to be shipped to Pennsylvania and especially to avoid purchasing them in districts where tuberculosis is prevalent.

I wish to call attention again to a statement made in my report of last year, which, upon further consideration, I regard as entirely feasible and worthy of adoption. Last year it was put forward tentatively but now I am convinced that a plan such as proposed below would be of great value to the live stock interest of the State.

"There is still much damage done by the sale of tubercular herds. When it becomes evident, through the death or debility of some of its members, that a herd is tubercular, some owners submit to the strong temptation to sell their cattle. They reason that, by so doing, they are violating no special law and that they will receive more for

their possibly diseased but still healthy looking cows than the State will pay, and they are escaping further loss. Of course there are manifest draw backs to conducting this sort of business in the locality in which one lives. So, such cows are usually sold to a dealer and are removed by him to some distant place, perhaps to another State. I believe that this sort of traffic should be discouraged by special legislation and by providing a safe market for tubercular cows. By a safe market, I mean such an outlet for them as exists in Switzerland, for example. In that country, cows found upon tuberculin test to be tubercular are not destroyed if they are still in the earlier stages of disease, but they are marked by cutting a piece out of the ear in a characteristic way, so that every one may know that the cow is tubercular. Then the sale of cows so marked is not prohibited but, by the obvious mark that is every where understood, every one is warned that this cow must, for the safety of the owner and his herd, be kept in such a way that disease cannot spread from her. This is easily accomplished by keeping the cow in a stable apart from healthy cattle, by having her pastured apart from them and by heating her milk to 165 degrees F. for ten minutes. Some of these tubercular cows when kept under these conditions continue to render useful service for two, three or even for four years. Cows that would be a source of great danger and loss in a herd may be kept in this way with profit. Their calves are almost always born healthy and may be reared in health if they are removed from their dams soon after birth, are kept away from tubercular cows and are fed on the heated milk of such cows or on the milk of healthy cows. If herds of cows in the early stages of tuberculosis were established, but only under inspection and quarantine, their milk could, with proper precautions, be used for many purposes and such herds would furnish a safe outlet for the reacting cows from other herds."

It is regretted that the funds at the disposal of the State Live Stock Sanitary Board are not sufficient to enable it to inspect all of the herds that are offered for inspection, but since it is not possible to do this the plan is adopted to make an inspection where the need appears to be greatest; that is, where there is the strongest evidence of existing infection. Since, on account of the financial limitations, all herds cannot be tested with tuberculin where owners apply for inspection, it is necessary to rely upon a physical examination for the detection and removal of the more advanced and therefore the more dangerous cases. By means of this method of inspection cattle with advanced tuberculosis or tuberculosis of the udder can be detected. At the same time, advice is furnished as to the general measures that should be adopted to restrict the spread of tuberculosis and also in respect to the improvement of the sanitary conditions surrounding the cattle. But tuberculosis cannot be fully

eradicated from a herd by means of this sort of inspection. It is resorted to for the purpose of removing the animals that are most dangerous at the time and thus afford a temporary relief until such time as it may be possible to make a complete inspection and tuberculin test.

During the year, about 16,000 cottle have been tested or otherwise inspected and of these 980 were found to be tubercular and were destroyed. The tubercular cattle were in 433 herds comprising 5,928 members.

The following paper from the laboratory of the State Live Stock Sanitary Board on the intercommunicability of human and bovine tuberculosis by Dr. Mazyck P. Ravenel is printed here because it furnishes a full statement of what has been done and the conclusions upon the important subject of which it treats. The paper was read before the Pathological Society of Philadelphia, April 24th, 1902, and is reprinted from the proceedings of the Pathological Society for May, 1902.

THE INTERCOMMUNICABILITY OF HUMAN AND BOVINE TUBERCULOSIS.

BY MAZŸCK P. RAVENEL, M.D., *Bacteriologist of the State Live Stock Sanitary Board.*

I find it difficult to express adequately my deep sense of the honor which has been paid me by the invitation of your committee to give the address of the evening on this occasion. The Pathological Society of Philadelphia has from its foundation had a most honorable position among the scientific bodies of the world, and has always stood for what is best and most advanced in the branch of medical knowledge to which it is particularly devoted. I have always felt it a high privilege to be able to inscribe myself a member, and to have the seal of the society put to such contributions as I have been able to make. More than this I never thought of aspiring to, hence the invitation to give this address was as unexpected as it was grateful to me.

The hesitation which I naturally felt over accepting such a responsible office was relieved, to a considerable extent, by the suggestion of your committee that I should speak on some phase of the tuberculosis problem, which has been an object of special study at the laboratory of the State Live Stock Sanitary Board of Pennsylvania, and in which I have had the constant advice and assistance

of Dr. Leonard Pearson, State Veterinarian of Pennsylvánia, and Dr. S. H. Gilliland, first assistant. The work I am about to report from our laboratory is the result of our joint efforts, and I take pleasure in acknowledging my personal indebtedness to these co-workers.

The past decade has seen the awakening of a wide-spread interest in the study of tuberculosis, the spirit of Oriental fatalism which has for so long led us to view with equanimity the awful loss of life annually inflicted by this great white plague having given away to an active campaign against its ravages, a campaign so far largely one of education, in which we strive to spread far and wide the fundamental facts that tuberculosis as a communicable disease, and from that fact, preventable. If preventable, why not prevented? With these precepts firmly implanted in the minds of the medical profession, as well as of the general public, we have reason to hope that each year will see a more careful study of the methods by which tuberculosis is spread and the means to be adopted for its prevention. On every hand societies for the prevention of tuberculosis are being formed whose object is to teach the truth concerning the disease and to dispel those false notions, chief among which may be mentioned belief in the hereditary character of tuberculosis, which in the past have led us to regard the tribute of human life as inevitable.

The intelligent prophylaxis against any disease demands a thorough understanding of the methods by which it is spread. The whole world is in accord in assigning the chief role in the propagation of tuberculosis to the inhalation of particles of sputum thrown off by phthisical persons, the majority of the profession agreeing with Cornet in the belief that sputum is most dangerous when dried and pulverized, while others follow Flügge in regarding the moist floating particles thrown out during coughing, sneezing, etc., as most to be feared. The danger to mankind from tuberculosis of cattle has been discussed at a length and with a fervor not surpassed in the history of modern medicine. The immense practical importance of the subject to the medical profession, to those charged with making and enforcing laws for the preservation of the health of the community, no less than to every man, woman and child, justifies our deepest interest, and most earnest studies.

The relation that exists between human and bovine tuberculosis and the part played by cattle in spreading the disease among mankind is now the great question, to which attention has been drawn with renewed activity by the attitude of Professor Koch, announced in his paper before the British Congress on Tuberculosis in July, 1901. This paper was the more striking in that it contained statements diametrically opposed to the former teaching of Koch that

"Bovine tubeculosis is identical with human tuberculosis, and is thus a disease transmissible to man.' This belief was the outcome of the experiments made by Koch at the time of his discovery of the tubercle bacillus, and has been generally accepted by the medical and veterinary professions up to the present time. So much has been written of late on the subject that I will pass over minor differences of opinion, and at once take up the consideration of the two main propositions which were formulated by Koch and which include all points of controversy in the discussion of the relation between human and bovine tuberculosis.

1. "Human tuberculosis differs from bovine and cannot be transmitted to cattle."

2. "Through the important question whether man is susceptible to bovine tuberculosis at all is not yet absolutely decided, and will not admit of absolute decision to-day or to-morrow, one is, nevertheless, already at liberty to say that if such a susceptibility really exists the infection of human beings is but a very rare occurrence. I should estimate the extent of infection by the milk and flesh of tuberculosis cattle, and the butter made of this milk is hardly greater than that of hereditary transmission, and, therefore, do not deem it advisable to take any measures against it."

I. The first of these propositions is susceptible of direct experimental investigation, and can, therefore, be answered positively without going into the domain of theory. Prof. Koch based this statement on the result of an insufficient number of experiments done by Prof. Shütz and himself. A number of young cattle proved to be free from tuberculosis by the tuberculin test were infected in various ways with the bacilli of human origin or with tubercular sputum. "In some cases the tubercle bacilli or the sputum were injected under the skin, in others into the peritoneal cavity, in others into the jugular vein. Six animals were fed with tubercular sputum almost daily for seven or eight months; four repeatedly inhaled great quantities of bacilli, which were distributed in water and scattered with it in the form of spray. None of these cattle (there were nineteen of them) showed any symptoms of disease, and they gained considerably in weight." After six to eight months they were killed, and no trace of disease was found in the internal organs. Where the injections were made, small foci of suppuration had formed, in which there were found a few bacilli.

Inoculations of a similar nature with bacilli from the lungs of an animal with bovine tuberculosis resulted always in rapid illness, ending often in death, while some were killed in a miserably sick condition after three months. In all cases there was extensive tuberculosis, involving the internal organs, especially the lungs and spleen.

A similar difference in pathogenic power was found in feeding experiments on pigs, where one lot of six received human tubercular sputum, and a second lot of six were given pure cultures of the bovine tubercle bacillus; and also in experiments on asses, sheep, and goats, where the inoculations were made with pure cultures of human and bovine bacilli into the circulation.

Results similar to these in the main have been obtained by Smith, Frothingham, Dinwiddie, and at the laboratory of the State Live Stock Sanitary Board of Pennsylvania, and we may admit that, as a rule, cattle show a high degree of resistance to the human tubercle bacillus, and that for all experimental animals the bovine bacillus has a pathogenic power equal to the human bacillus, while for the great majority it is vastly more pathogenic; but this does not by any means show that man is not susceptible to infection by the bovine organism, and we have abundant proof that it is quite possible to infect cattle with the tubercle bacillus from human sources.

The identity of tuberculosis as seen in man and cattle was held by Villemin, who believed he had proved the correctness of this view in his inoculation experiments, by which he showed conclusively that small animals like rabbits become tuberculous following the injection of material from man as well as cattle. Chauveau[5] was, however, the first to make the attempt to infect cattle with tubercular material from man, and his success is shown in the following abstract of his experiments:

First Series.—*Infection by the Digestive Tract.*—Three animals were used, and as controls there were three other similar animals which were infected with bovine material, and also three which were not infected at all, these last remaining free from tuberculosis. Those to which bovine material had been fed as well as those which received human material became tuberculous. At the autopsy it was impossible to distinguish one set from the other. In all of them the lesions provoked showed the same character. The individual histories of the three animals infected with human material are as follows:

1. A heifer, six months old, which received material from the lung of a young man dead of acute miliary tuberculosis. Two doses of an emulsion of this material were given morning and evening of the same day. It was killed on the fifty-seventh day, having lost flesh to a slight degree. The lesions were found almost exclusively in the abdominal cavity. In the small intestine there were more than two hundred tubercles varying from the size of a pea to that of the head of a pin. The liver contained upward of a dozen small tubercular masses on its surface. The peritoneum showed a marked eruption of tubercles.

2. A heifer, eleven months old, which received two feedings with an interval of two days, the material being taken in part from the lung of a child with acute miliary tuberculosis and in part from the lung of an adult with a marked chronic phthisis with caseation. The animal soon became sick, and during life tuberculosis could be detected. The submaxillary ganglion on the right side became enlarged about the fifteenth day, and increased steadily until the animal was killed on the fifty-ninth day. The intestinal tract was only slightly involved, but the ganglia related to the first portion of the digestive tract showed marked lesions. The right submaxillary and the retropharyngeal glands were considerably enlarged and showed a typical tuberculosis with some calcification. The principal lesions were found in the thoracic cavity. In the lung were a dozen disseminated foci mostly superficial, most of which showed caseous points on section. Microscopical examination showed them to be made up of a great quantity of lymphoid cells, with some giant cells. In the neighborhood of these masses and also in areas far from them were found diffuse tubercles developing into the alveolar tissue, as well as in the perivascular and peribronchial connective tissue. These young lesions showed exactly the same histologic structures as the larger ones. The bronchial and mediastinal glands were also markedly involved.

3. A young bull, about ten months old, which received two feedings on two consecutive days, composed of an emulsion made from the lung of two persons who had died of chronic phthisis (caseous pneumonia). After a diarrhea, which lasted several days, the animal showed marked illness, and lost flesh. It soon began to cough, and so marked were the symptoms that it was slaughtered on the thirty-fourth day. In the small intestine there was a marked eruption of tubercles extending from about the second portion of the jejunum to the end of the ileum. In certain portions the mucous membrane was converted into confluent tubercles. The most interesting lesions were found on the mucous membrane of the respiratory tract. In the larynx and the upper part of the trachea were found masses of gray granulations, a few of which were red and ulcerated.

Second Series.—*Infection by Intravenous Injection.*— A calf, three months old, was inoculated into the jugular vein with 2 c.c. of an emulsion made from the lung of a child with acute miliary tuberculosis. It was killed on the twenty-ninth day. The lesions were confined to the chest, the bronchial and mediastinal ganglia showing the most marked changes. In the lung, on section, there were found well-marked gray granulations accumulated in the interior or around the small bronchi, which they sometimes occluded entirely. This was well seen with the naked eye, but was better demonstrated in microscopical sections.

Third Series.—*Infection by Subcutaneous Inoculation.*—Seven animals were inoculated. For three animals the material used was obtained from fungus masses from the joints in cases of white swelling; for three others from acute miliary tuberculosis, and in one from the lung of a horse which had developed a marked pulmonary tuberculosis due to the intravenous injection of material from the lung of a man. In all cases a tumor developed at the point of inoculation, which Chauveau describes as being a tuberculous tumor altogether typical. The neighboring glands showed always more or less involvement, but in no cases was there any general infection.

I have quoted these experiments at some length for the reason that they seem often to be overlooked, and for the further reason that they have recently been directly misquoted. Indeed, Koch himself said in his address before the British Congress on Tuberculosis, "If one studies the older literature of the subject, and collects the reports of the numerous experiments that were made in former times by Chauveau, Gunther and Harms, Bollinger, and others, who fed calves, swine, and goats with tubercular material, one finds that the animals that were fed with the milk and pieces of the lungs of tubercular cattle always fell ill of tuberculosis, whereas those that received human material with their food did not."

Bollinger, in 1879, inoculated a young calf in the peritoneal cavity with material from a human lung. When killed after seven months the mesentery and peritoneal covering of the spleen presented a number of tumors from the size of a pea to that of a walnut, and which microscopically were identical with those found in pearl disease under natural conditions. The retroperitoneal and mesenteric glands were tuberculous also.

Klebs caused a tuberculosis of the peritoneum identical with that which is seen under natural conditions by the intraperitoneal injection of human tubercular material. Kitt, also, is quoted by Professor Johne as having had a similar result accompanied with generalized lesions following the intraperitoneal injection of the juice from a scrofulous gland taken from the neck of a man.

Crookshank injected tuberculous sputum into the peritoneal cavity of a calf, causing death on the forty-second day. The autopsy revealed extensive disease. "Extending over the mesentery from the point (inoculation) there were hundreds of wart-like, fleshy new-growths, some quite irregular in form, others spherical or button-shaped. There were similar deposits on the under surface of the liver, on the spleen, in the gastrosplenic omentum, and on the peritoneal surface of the diaphragm. On microscopic examination extremely minute tubercles were found disseminated throughout the lungs and liver. Tubercle bacilli were found in these organs and in the peritoneal deposits."

Sydney Martin fed human tuberculosis sputum to six calves. Four of these received each 70 c.c. mixed with their food at one meal. They were killed after 33, 63, 85, and 285 days. The first three showed respectively 53, 63 and 13 tubercular nodulesin the intestine, while the fourth was entirely free. The two other calves were given 440 c.c. of sputum at one feeding. One was killed after fifty-six days, and showed tuberculosis of the intestine and mesenteric gland. The other was allowed to live 138 days, and was free from disease when killed.

At the recent Congress on Tuberculosis, Prof. Thomassen, of Utrecht, reported the following experiment: A calf four weeks old was inoculated in the anterior chamber of the eye with a pure culture of the tubercle bacillus isolated from a case of tuberculous arthritis in man. An intense keratitis was set up, the cornea becoming so opaque that it was impossible to observe the alterations in the iris. It was killed after six weeks, and was found to be the victim of a pretty well generalized tuberculosis. Both lungs contained numerous miliary tubercles and some gray fibrous tubercles of larger size. The path of infection from the eye to the lung was mapped out by the condition of the subparotideal, cervical, mediastinal, and bronchial lymph glands of the same side.

Nocard states that by inoculation into the arachnoid cavity of a small amount of human tubercle bacilli a rapidly fatal tubercular meningitis is set up identical with that seen in children. A calf, five months old was thus inoculated by him on August 2, 1901, and died on the 28th of the same month, the pia mater being infiltrated with tubercles which proved virulent for guinea pigs.

On the same day Nocard injected into the jugular of a cow which had become much reduced by chronic diarrhea, but which was free from tuberculosis as shown by the tuberculin test, 1 c.c. of a suspension of human bacilli. She died September 4th, and showed a number of small foci, softened or caseous and extremely rich in tubercle bacilli. He considers that in this case the animal was so weakened by the pre-existing diarrhea that its normal resistance was largely destroyed.

De Jong as the result of a series of comparative inoculations of human and bovine tubercle bacilli, states that seven cattle, namely, two calves six months old, three steers two years old and one eighteen months, and one calf seven or eight months old, all became tuberculous by the injection of pure cultures of the human tubercle bacillus. In only one of the seven was the disease grave and widespread; in four the lesions were retrogressive, and in the two remaining ones progressive.

Arloing reports the following recent experiments: Three cultures of human origin were used, one of which had been under cultivation

since 1896. With this culture a heifer, two years old, and a young calf were inoculated intravenously. The calf was killed after thirty-two days, and showed a typical eruption of minute tubercles all through both lungs, but especially marked in the anterior lobes. The heifer was kept for one hundred and twenty days, and was only slightly diseased, the lungs and pleurae being involved. With the second culture, obtained from a case of pleurisy, a calf two and one-half months old was inoculated intravenously. Death ensued after seventeen days. The lungs alone were involved, showing many young nodules. The third culture was isolated from a case of pleuropericarditis, with involvement of the lungs, and with this a young bull convalescent from aphthous fever was inoculated intravenously, death resulting in thirty-two days. The thoracic cavity was principally involved, the anterior and middle lobes containing nodules throughout, and some lobules of the posterior lobes also. The bronchial and esophageal glands were tremendously enlarged, weighing thirty-five kilograms.

It may be objected to many of these experiments that the tuberculosis resulting from the inoculation did not cause death nor even serious illness, and it is probable that some of the animals would have recovered entirely if allowed to live. Admitting freely the truth of this, it may be pointed out that under natural conditions many cattle infected with bovine tuberculosis will remain for years apparently in perfect health, so much so that detection of the disease is possible only by means of tuberculin. So, also, in man, many cases of tuberculosis run a benign course, or remain stationary for years, while not a few end in recovery. Yet in man and in animals these benign cases may take on an acute form and end in rapid death, owing to some intercurrent affection which lowers resistance or permits the engrafting of a secondary infection. No one would hold that because of the benign course of the disease in the first instance that true tuberculosis did not exist.

Transmission of Tuberculosis to Cattle from Phthisical Attendants.—There are on record a few instances of cattle becoming infected with tuberculosis through the sputum of phthisical attendants. In several of these the evidence is so clear as to leave no doubt that cattle art at times infected in this manner. Such instances have been reported by Cozette, Clique, Huon, director of the vacine laboratory at Marseilles, and Bong. In most of these cases the sputum was introduced into the digestive tract with the forage, as well as inhaled in the dry state, but in Huon's animal the infection seems to have been entirely through inhalation.

Experiments at the Laboratory of the State Live Stock Sanitary Board.—I come now to speak of the work done at the laboratory of the State Live Stock Sanitary Board, the results of which you see

illustrated in the specimens presented here for your inspection and study. I cannot but feel that these specimens possess an unusual interest and importance in the solution of a problem which is now engaging the attention of scientific men throughout the world, and which has been made the subject of special investigation by the governments of many countries. Our first successful attempt to infect cattle with human tuberculosis was made in 1898, when four calves of nearly the same age, four to five weeks old, received intraperitoneally 10 c.c. of human tuberculous sputum, from different sources, but in all cases containing a large number of bacilli. One showed no ill effects except a slight rise in temperature, and the autopsy was entirely negative.

Of the other three, two had persistent high temperature following the injection, but only one showed marked illness otherwise. Postmortem examination proved that all had become infected with tuberculosis, the lesions in two being quite extensive. I will give here the details of only the one which showed marked illness during life. The lesions were so extensive and typical that even the most skeptical must admit the success of the experiment, and I have here some of the organs for inspection.

Calf No. 8050, aged four weeks, was inoculated on May 16, 1898, with sputum from an early case of pulmonary tuberculosis at the University Hospital. The sputum contained a large number of tubercle bacilli. Soon after the operation the temperature of the calf rose and continued high, with some remissions, until it was killed. Its appearance was bad, the coat dry and rough, the respiration rapid. It was tested with tuberculin, but the temperature was too high for results. It was killed on August 1st, weighing 190 pounds. On the surafce of both lungs there was a slight deposit of fibrin, and on section a number of hemorrhagic areas were observed in both. The mediastinal and bronchial glands were enlarged and congested. The abdominal cavity contained about 12 ounces of bloody serum. The peritoneum was thickly studded over its entire surface with nodules from 1 mm. to 12 mm. in diameter, fibrous in character. In many places these nodules had massed together, forming tumors, some 5 cm. in diameter, which were dense and fibrous. The spleen contained many nodules, both on its surface and throughout its substance. The whole omentum was thickly studded with nodules from 2 mm. to 12 mm. in diameter, and besides which there were three large masses, dense and fibrous in character, two of which were 15 cm. long by 7 cm. wide, and 12 mm. thick; and the third 7 cm. long by 6 cm. wide, by 4 cm. thick. The abdominal surface of the diaphragm was thickly studded with nodules, fibrous in character. The

mesentery was thickened and contained many nodules of small size. The appearance was that of a typical case of grape or pearl disease. The mesenteric and mediastinal glands were enlarged and somewhat caseous.

For several years past we have endeavored to obtain material from cases of tuberculosis in children in which there was evidence of infection through the ailmentary tract, reasoning that if children contracted tuberculosis through the ingestion of milk from diseased cattle we would be most apt to find bacilli of the bovine type in these intestinal or mesenteric lesions. So far only three such cases have come to us, all through the kindly interest of Dr. Alfred Hand, and in only one of these was the evidence of primary intestinal infection clear. We have isolated from the mesenteric gland of this child, the immediate cause of whose death was tubercular meningitis, a culture which has for cattle the most intense pathogenic power. Two calves inoculated into the jugular vein and peritoneal cavity died in nineteen and twenty-seven days respectively; and a grown cow was inoculated both in the jugular vein and peritoneal cavity died in eighteen days. All of these animals exhibited marked symptoms from the day of inoculation. Examination of the lesions, both macroscopic and microscopic, leaves no doubt that the animals succumbed to a pure tuberculosis. The details of these cases are as follows:

History of Culture.—Designated BB. Obtained from a child seventeen months old. Death was due to tubercular meningitis. Autopsy: Lungs normal, except posterior part of the right upper lobe, which was consolidated, red on section, and had excess of connective tissue. Bronchial and mediastinal glands not enlarged. Spleen, liver and kidneys show pearly tubecles. Two feet from lower end of ileum is an ulcer 1 cm. by 2 cm., the long diameter transverse to axis or gut. Nodules are seen on peritoneal surface. Four small ulcers, two above and two below, are found in ileum, Mesenteric glands enlarged, cheesy, and some purulent. Meninges show yellow tubercles most marked along longitudinal fissure, in choride plexus and over cerebellum. The mesenteric glands were used in obtaining the culture.

This case is considered by Dr. Hand the clearest one of primary intestinal tuberculosis ever seen by him.

Guinea-pigs were inoculated intraperitoneally with an emulsion made from the mesenteric glands on March 9, 1901. One was chloroformed on April 19th, and cultures made. Scanty growth on one tube was found on June 8th, and subcultures made.

Calf No. 26596, weight 132 pounds. Tested with tuberculin, but gave no reaction. On December 4, 1901, 5 c.c. of a suspension of the fifth and sixth generation of culture BB were injected into the right

jugular vein. On the next day the temperature had risen to 103.2 F. After a slight remission it rose to 103 degrees F. on the seventh day after inoculation, and continued to rise each day, reaching 106.4 degrees F. by the fourteenth day, after which it fell slightly until death which took place on December 21st, seventeen days after inoculation. The animal showed marked illness during life, the respiration reaching 68 per minute.

Autopsy.—The lungs and the related glands showed macroscopically the most marked disease. Both lungs were thickly studded throughout, with remarkable uniformity, with miliary nodules giving a sandy feel under the finger. The left was pneumonic, owing to the position of the calf for some time before death. Portions of the right were in a similar condition, sinking when placed in water. The bronchial and mediastinal glands were much enlarged and soft, and in the former small areas of caseation were found.

The liver was large, soft, and friable. Several nodules were visible on the surface, though not perceptible to the touch. The spleen showed very slight changes. The kidneys were normal.

Calf No. 26597, weight 202 pounds. Tested with tuberculin, and gave no reaction. On December 4, 1901, 5 c.c. of a suspension of Culture BB of the fifth and Sixth generations were injected into the peritoneal cavity. The temperature rose to 105.2 degrees F. by the eighth day after injection, remaining very nearly the same until four days before death, when it began to fall, and reached 103 degrees F. on the day before death, which took place on December 31st, or twenty-seven days from the time of inoculation.

Autopsy.—Great emaciation. Loss in weight thirty-seven pounds. The lungs were largely involved, though not uniformly. The central and posterior portions showed many areas deep red in color and solid to the feel. These were thickly studded throughout with minute grayish nodules.

The suprasternal lymph glands were as large as goose eggs, and contained cheesy areas. The mediastinal glands were much enlarged, one being six inches in length by two inches in diameter. The peritoneal cavity contained about six quarts of straw-colored fluid. The peritoneum was everywhere enormously thickened, and practically converted into a tuberculous mass. In several places it was one-half an inch thick and fibrous. The omentum was also enormously thickened and bound over the surface of the liver. It contained a great number of nodules, dense and fibrous, many with caseous centers. The liver was firmly adherent to the diaphragm, and on section showed many nodules. The spleen was firmly attached to the surrounding parts by a mass of partly organized fibrin, which contained many cheesy nodules. On section it appeared to be normal.

Cow No. 45030, about three years old, and weighing 660 pounds. On January 22, 1902, 2½ c.c. of a suspension of Culture BB of the seventh and eighth generations were injected into the right jugular vein and the same amount into the peritoneal cavity. The temperature rose to 103.2 degrees F. on the second day, then fell slightly during the next six days, after which it rose steadily, reaching the maximum, 107 degrees F., three days before death, after which it fell slightly, the animal dying seventeen days after inoculation. The lungs were mostly involved, both being thickly studded throughout with miliary nodules. Most of the left lung showed interlobular emphysema, while the inferior portion was much congested. On the omentum were numerous dark red spots which could be felt between the fingers. The spleen was adherent to the diaphragm, and there were many punctate hemorrhages on the surface. The liver and kidneys showed no gross changes.

What interpretation is to be given to these remarkable results? One of two propositions must be admitted: either we have found a human tubercle bacillus having a pathogenic power for cattle quite as great as any bovine germ, or else we have found in the mesenteric gland of a child the bovine tubercle bacillus. If we accept the law of diagnosis laid down by Koch, namely, the inoculation test, the latter is the true explanation. I, myself, am strongly of the opinion that this latter is the case for the following reasons:

1. The history of the case as given by Dr. Hand of primary intestinal infection.

2. Morphologically and culturally the organism corresponds more nearly to the bovine type as first defined by Dr. Theobald Smith, and later by ourselves, than the human.

3. The great pathogenic power for cattle.

A second culture obtained from the mesenteric glands of a child has shown a virulence far in excess of that usually found in human cultures, through it falls short of Culture BB in pathogenic power. This culture, designated U, was isolated in December, 1900, and tested for guinea-pigs and rabbits. The results, together with its manner of growing and microscopic appearance, lead us to consider it a typical human culture. During the summer of 1901 it was selected for some feeding experiments on puppies, and showed a degree of virulence that was not expected. In December last, wishing to produce a slow tuberculosis in a dog, this culture was again employed. The dog grew ill rapidly, and died in January, thirty-six days from the time of inoculation. Post-mortem examination revealed a typical and extensive tuberculosis and it was decided to inoculate a calf in order to test its virulence for the bovine race. On March 4, 1902, Calf No. A 45046, weighing 74 pounds, was inoculated in the jugular vein with 6 c.c. of a suspension of Culture U, of the

twelfth generation, from glycerinagar, the suspension being equal in opacity to a twenty-four-hour-old culture of the typhoid bacillus in bouillon. The animal soon showed signs of illness, the breathing became rapid and labored, reaching 54 per minute. Extreme weakness and depression came on, and it passed much of the time lying down. On April 19, 1902, it was killed, death seeming imminent.

Autopsy.—Weight 82 pounds. Condition fair. The anterior lobes of both lungs were thickly studded with minute nodules, averaging 1 mm. in diameter. Blocks from these lobes sank in water immediately. Both lungs were dense and solid to the feel throughout. The posterior lobes were air-bearing for the most part, but contained many solidified areas, which could be seen on the surface as well as on section.

The bronchial and mediastinal glands were enlarged and wet. Scrapings from cut surfaces show an enormous number of tubercle bacilli. In the mediastinal glands many yellowish nodules were seen. The pleurae were normal. The liver was enlarged and firm to the touch. No distinct nodules could be seen by the naked eye, but throughout the substance yellowish areas were found in large numbers. The surface appeared marbled.

The spleen was enlarged and very firm, but no nodules could be detected. The kidneys showed numerous whitish areas on the surface, which were found to extend quite deeply into the cortex. On section many yellowish nodules were seen. The tissues of the kidneys were much stained with bile, and the pelvis contained a gelatinous or viscous material showing the same pigment. The peritoneum was normal.

Microscopic Examination.—The solidified portions of the lungs contained large areas which are not air-bearing, the alveoli being completely filled with leukocytes and epithelium, or epitheloid cells. The small bronchi are filled by an exudate made up largely of leukocytes. The central portions of the nodules stain poorly, and fragmentation of the nuclei of the cells is seen, but no distinct caseation can be found. In sections stained with carbol-fuchsin innumerable tubercle bacilli are seen. In other parts of the lungs which are still largely air-bearing, minute nodules are found in large numbers having the same general characterists as those just described. Throughout the sections many tubercle bacilli are seen, and in the nodules they are in clusters. In the liver no typical tubercles are found, but there are many minuate nodules made up of round cells, and on the borders of these a considerable number of giant cells with peripheral nuclei occur. Sections stained with carbol-fuchsin show large numbers of tubercle bacilli clustered in these areas.

The spleen shows round-cell infiltration, giant cells, and many tubercle bacilli.

The white areas in the kidney described above show a round-cell infiltration and large numbers of tubercle bacilli. The bronchial glands show areas of beginning caseation, a few giant cells, and innumerable tubercle bacilli.

This calf showed a well-marked tuberculosis, proving that the culture with which it was inoculated had a degree of virulence above that usually found in cultures of human origin. Our experience with this culture leads us to believe that the usual method of employing only guinea-pigs and rabbits in testing the virulence of the tubercle bacillus does not always give entirely conclusive results. Unfortunately, the expense attending the use of larger animals hinders their more general employment.

History of Culture V.—Obtained from a child, aged three years, whose death was due to tubercular meningitis. Autopsy: Lungs and bronchial lymphatic glands full of miliary tubercles. Anterior mediastinal glands much enlarged. Spleen extensively involved, liver less so. On the abdominal surface of the diaphragm were a number of flat, yellow nodules. Mesenteric glands enlarged, and contained old, yellow, cheesy nodules. One small tubercle found in the right suprarenal. Purulent and cheesy nodules found in meninges and encephalon. The cultures were obtained from the mesenteric glands.

The pathologist, Dr. Hand, was unable to decide with certainty as to the origin of this case.

Increase of Virulence by Successive Passage through Calves.—In another experiment instituted by Dr. Leonard Pearson we have proved that a typical tuberculosis can be produced in young cattle by large and repeated doses of a human culture of moderate virulence; and what is even more interesting and important, by successive passages through calves we have succeeded in bringing about a marked increase in the virulence of this culture. The culture employed was isolated from human sputum in September, 1899, and is designated "M." The animals were inoculated at intervals of a week, the amount of culture being divided into four equal portions, which were injected into the jugular vein, the lung, the peritoneal cavity, and under the skin. Each week the dose was increased by 10 c.c.

Two calves were infected in this manner, Nos. 26562 and 26563. With the tissues of No. 26562 the serial inoculations were begun, the details of which, with the postmortem examination of the animals, is given below. The result is shown in the following table:

No.	Amount of injection	Length of life.
1. Calf . 26562,	925 c.c.	106 days
2. Calf A45020,	16 c.c.	48 days
3. Calf A45035,	13 c.c.	23 days
4. Calf A35047,	10 c.c.	24 days
5. Calf A45073,	14 c.c.	24 days

Calf No. 26562, weight 210 pounds. The first inoculation was made on September 6, 1901, and thereafter at intervals of a week, until December 16th. Each time the total amount was divided into four equal parts and injected subcutaneously, intraperitoneally, into the lung, and into the jugular vein. The commencing dose was 10 c.c. of an emulsion equal in opacity to a twenty-four-hour-old bouillon culture of the typhoid bacillus, the total amount given being 925 c.c. The temperature rose after each injection, and remained high for two days, then fell gradually, though normal was never reached. About five weeks after the first injection the calf began to cough. This cough grew steadily worse until death, being most marked on the day following each injection. Respiration grew labored, and the animal lost flesh. By December 15th it was markedly ill. Death took place during the night of December 21st.

Autopsy.— Considerable emaciation. The lungs were hard and firm to the touch. The various sites of inoculation could not be detected, and there were no abscess cavities nor scars. The lungs were dense throughout and heavy, through sections floated in water. The bronchi, especially the smaller ones, were filled with a tenacious mucus, in which many tubercle bacilli were found. An emulsion made from one of them showed many tubercle bacilli. The mediastinal glands were large and soggy, but no nodules could be found. The bronchial glands were enlarged, and a few caseous points were found. An emulsion made from one of them showed many tubercle bacilli. The mediastinal glands were large and soggy, but no nodules could be found. The liver was attached to its capsule at points which were the sites of flat, yellowish nodules, from 2 mm. to 5 mm. in diameter. On section tuberculous areas of considerable extent were found, reaching from the surface to a depth of 3 cm. The spleen was much enlarged and very soft. On the surface were a number of flat fibrous new-growths. The kidneys showed no changes. The omentum was much discolored, having a dirty, brownish appearance, and in parts much thickened. It contained upward of 100 nodules of 2 mm. to 6 mm. in diameter, some gray, some white, and some hemorrhagic. Some had the appearance of beginning "grape" formation. The mesentery presented the same appearance. Its glands were enlarged and wet, but no cheesy nodules could be found. On the parietal peritoneum were a large number of pearly

nodules, 2 mm. in diameter, and a few sessile new-growths, some of which were hemorrhagic, and had fringes of fibrin hanging from them. Microscopic examination of the tissues showed the spleen and kidneys to be free of tubercles. In the lungs the greater part of both is made up of conglomerated tubercles which show very little central caseation. The alveoli are completely filled with desquamated epithelium, leukocytes, and epitheliod cells. There is a marked bronchitis.

Calf No. 26563, weight 165 pounds. The first inoculation was made on September 6, 1901, and thereafter weekly until December 16, 1901, when an interval of nineteen days was allowed to elapse, the inoculations being resumed on January 4, 1902. The method of inoculation was the same as for Calf No. 26562. Death took place January 22, 1902, the total amount of the suspension of the culture given being 1100 c.c. The condition of the animal following the injections correspond closely with Calf No. 26562, its survival being somewhat more prolonged.

Autopsy.—Weight 186 pounds. Considerable emaciation. The lungs were firm and non-elastic to the touch. The points of inoculation could not be detected either in the pleurae or in the lungs, except at one point, where a small pus cavity, 1 cm., was found near the surface of the right lung, the pus containing many tubercle bacilli. No district nodules could be found in either lung, but both were much increased in solidity throughout through sections would float in water. The bronchi were filled with a tenacious mucus. The pleurae were roughened by bands of fibrin, which extended to the lung, attaching the inferior borders especially to the chest-wall. The bronchial and mediastinal glands were much enlarged, and the latter contained many caseous nodules. In the abdominal cavity all the organs were attached to the peritoneum and to each other by bands of fibrin. The liver was firmly adherent to the diaphragm. Over the surface were fifty to sixty whitish, flat nodules, 5 mm. to 100 mm. in diameter some of them extending deeply into the substance of the organ. On section caseous areas were seen.

The spleen and kidneys showed slight changes only. The parietal peritoneum was rough at many points and had fringes of fibrin attached to it. Scattered over it were a large number of gray nodules, 2 mm. to 5 mm. in diameter.

Microscopic examination showed no well-defined tubercles in the spleen and kidneys. The liver showed many areas of necrosis. In the lungs were masses of conglomerated nodules, most of which did not show marked central caseation. Numerous giant cells were found. The alveoli are filled with desquamated epithelium, leukocytes, and epithelioid cells. There is a marked bronchitis.

Calf No. 45020, six months old. On December 23, 1901, 8 c.c. of an emulsion made from the bronchial gland of Calf No. 26562 were injected into the left lung, and the same amount into the peritoneal cavity. The emulsion showed many tubercle bacilli. By January 15, 1902, the calf was markedly ill, and breathing was increased in rapidity. These symptoms increased steadily, the temperature ranging from 104 degrees F. to 105.5 degrees F. About February 1st the temperature began to fall, and at the time of death, February 9th, was subnormal.

Autopsy.—Much emaciated. Both lungs were a dark red, and were thickly sown throughout with miliary nodules. The left lung was adherent to the chest-wall over a large part of its surface. On separating it many tubercular new-growths were seen, between which the pleura was smooth. At the point of inoculation was an abscess cavity 4 cm. in diameter. The pus contained many tubercle bacilli and staphylococci. On the lung over the abscess, and binding it lightly to the chest-wall, was a layer of fibrin, of cream-white color. Along the backbone was a chain of enormously enlarged glands fitting into the spaces between the ribs, and extending from the first rib to the diaphragm. These were filled with caseous areas. The mediastinal glands were enlarged and showed many caseous areas. Most striking was the condition of the omentum, which had been converted into a mass of tubercular new-growth, made up of conglomorate nodules. It varies in thickness from 1 cm. to 3 cm. The nodules are grayish-yellow, fibrous, and show central caseation. The liver shows numerous yellowish nodlues, both on the surface and on section.

The spleen has on its surface a number of flat, fibrous newsgrowths, but no nodules are seen on section.

The kidneys are normal in appearance, but a few nodules appear on section.

Microscopic examination shows the lungs to be thickly sown with minute tubercles. Sections stained with carbol-fuchsin show innumerable tubercle bacilli clustered mainly in these nodules. The liver contains many necrotic areas in which many tubercle bacilli are found. The spleen contains a considerable number of necrotic areas. The flat new-growths are tuberculosis. The kidneys show only a few tubercles, which contain innumerable tubercle bacilli.

Calf No. 45035, aged nine weeks, weight 130 pounds. February 11, 1902, inoculated into its right lung and peritoneal cavity with an emulsion made from the omentum of Calf No. 45020, 5 c. c. being injected into the lung, and 8 c. c. into the peritoneal cavity. The temperature rose on the day after the inoculation, and reached 107 de-

grees F. on the third day, after which it fell, and ranged from 104 degrees F. to 106 degrees F. until a few days before death, when it fell slightly, going as low as 101.4 degrees F. on the day of death. Breathing had become labored ten days before death, and the appetite failed a week before death, which took place March 6.

Autopsy.— Weight, 97 pounds. Condition, fair. The right lung adherent to chest-wall throughout. When separated a layer of fibrin containing many tubercular masses of new-growth is seen. At the point of inoculation is an abscess cavity 4 cm. in diameter, the pus containing many tubercle bacilli and a gas-forming bacillus of the colon group. Both lungs were filled with a multitude of minute nodules, and some areas showed extensive caseation. The mediastinal and bronchial glands were very much enlarged and caseous.

The liver, spleen, and kidneys were normal in appearance.

The omentum contained a very large number of discolored, reddish areas, which were thickened, hard, and of sandy feeling.

Microscopic Examination.—The lungs are studded with minute tubercles. The liver contains many small areas of necrosis. The spleen shows a number of areas of commencing necrosis. The kidneys are normal.

Calf No. 45047, aged six weeks, weight 72 pounds. Inoculated March 7, 1902, with an emulsion made from the lung and bronchial gland of Calf No. 45035, 5 c. c. being injected into the right lung, and 5 c. c. into the peritoneal cavity. The temperature rose to 104.8 degrees F. to 106 degrees F. for ten days, then fell slightly until death took place, on April 1, 1902.

Autopsy.—Weight, 65 pounds. Considerable emaciation. Both lungs are studded throughout with miliary nodules. The right lung is firmly attached to the chest-wall for its entire surface, and at the point of inoculation is an abscess 4 cm. in diameter, which contains a milky fluid pus in which are curdy masses. The pus contains many tubercle bacilli and other bacteria, but no streptococci. The left lung is attached to the chest-wall for a third of its surface. Over the unattached surface is a layer of fibrin, 1 mm. in thickness. The chest-wall corresponding to this fibrin is thickly studded with minute gray nodules. The pericardium is attached to the lung. The heart shows numerous yellowish tubercles scattered over the ventricles, as well as the auricles, and especially numerous on the auricular appendage. They are seated in the visceral layer of the pericardium.

The bronchial and mediastinal glands are enlarged and soggy, but no nodules can be found.

The omentum contains innumerable minute pearly nodules, and many red, fleshy, highly vascular new-growths.

The mesentery of the large as well as small intestine contains innumerable pearly nodules. The mesenteric glands are normal in size and appearance. Along the abdominal aorta and brim of the pelvis are twelve to fifteen glands from 5 mm. to 15 mm, in diameter, yellow in color, but none caseous.

The liver is adherent to the diaphragm. On the surface, as well as on section, many yellowish nodules can be seen.

The spleen is thicker than normal and very firm. On the surface a few fibrous new-growths are seen.

The kidneys appear normal, but each has a layer of the peritoneum attached to it, which contains innumerable gray nodules, averaging 1 mm. in diameter.

Microscopic Examination.—Lung not examined. The liver contained many minute areas of necrosis. The kidneys contain a considerable number of minute tubercles, with central necrosis, situated for the most part immediately under the capsule.

Another animal was inoculated in the same manner with the tissues of this calf, which is still living.* Guinea-pigs have also been inoculated in order to recover a pure culture, so that any changes that have taken place may be studied. We feel, however, that we have demonstrated a great increase in virulence in this culture, obtained from sputum, by the several passages through calves.

Our own experiments, as well as those quoted from others, demonstrate that Koch's statement that human tuberculosis cannot be transmitted to cattle is erroneous and untenable.

II. In the second proposition Professor Koch calls in question the possibility of the transmission of tuberculosis from cattle to man, and holds that if such transmission ever does take place it is a very rare occurrence, so rare, indeed, as to render superfluous any measures of precaution against it.

In the solution of the problems here involved we are of necessity deprived of experimental data, so must gather evidence from every possible source, collate and weigh it carefully, in order to draw fair conclusions.

In the first place, we may well ask if tuberculosis in cattle is marked by any specific features which differentiate it from tuberculosis in man, and which would make it improbable that the two were intercommunicable. I will not attempt here to go into a discussion of all the forms of bovine tuberculosis or to compare it minutely with the disease in man. The chief differences are: (1) The marked tendency to calcification rather than the caseation seen in man; (2) the formation of extensive new-growths in the serous membranes, such as the pleurae and peritoneum.

*This calf, No. A45073, died three days after the reading of the paper, or twenty-four days after inoculation. There was typical and extensive tuberculosis.

These growths assume wart-like, or cauliflower, or grape-like shapes, from which the names "perlsucht," "pearly disease," "pommeliere," and "grape disease," as applied to bovine tuberculosis, are derived.

In cattle, as in man, the lungs are the chief seat of the disease. In about half of all cases the lungs and serous membranes are simultaneously affected; the lungs alone in about one-third, and the serous membrane alone in about one-fifth.

Since 1863 Virchow has insisted that the two tuberculosis were distinct, an attitude reaffirmed by him in his latest publication, his chief point being that we cannot call anything tuberculosis which does not show the true histologic tubercle, whether or not the tissues contain tubercle bacilli and show changes due entirely to them. Although insisting so strongly on this distinction, which is not held by all pathologists, Virchow does not accept Koch's conclusions, and says that in the postmortem examinations at the Charité several cases have been found showing an unusual peritoneal tuberculosis, with enormous growths, such as are seldom seen in man. These cases he regards as being possibly of bovine origin through food.

The histologic identity of human tuberculosis and pearl disease was first demonstrated by Schüppel and his work has been supplemented by Baumgarten, who has observed characteristic caseation such as occurs in the human tubercle, take place in the nodules of pearl disease, "in a typical form and with like regularity." The process is often obscured by rapid calcareous changes which, he justly remarks, are terminal, and have nothing to do with the actual disease, and which, furthermore, are often seen in human tuberculosis. On the other hand, it has repeatedly been shown that typical miliary tuberculosis can be produced in cattle by the bovine bacillus, and as seen in the specimens before you the same result may be brought about at times by the human bacillus. In fact, experimental tuberculosis in cattle induced by inoculation with the bovine tubercle bacillus is usually of the miliary type, and only exceptionally assumes the form considered typical of the natural bovine disease. In this connection Hueppe very aptly calls attention to the fact that Koch in his experiments with the bacilli of bovine tuberculosis produced in cattle "only tuberculosis, but not the tuberculosis of the pleura peculiar to the ox—the so-called perlsucht; his experiments, therefore, in the sense of his special interpretation, did not even prove that bovine tuberculosis affects the ox." It has further been shown by Troje, and by Dr. Theobald Smith, that pearl disease may be produced in rabbits by the human tubercle bacillus. Troje has observed one case of pearly disease affecting the pleura in man.

The differences noted between tuberculosis of man and tuberculosis of cattle are scarcely greater than those noted between the latter and tubreculosis of swine, yet nothing is easier than to infect swine with the milk or other products of tuberculous cattle. The infection here is by natural methods, and in fact is most often noted where nothing was further from the wishes or intentions of the unconscious experimenter. The origin of the infection is unquestionably bovine, yet the disease produced differs markedly, but not essentially, from that seen in cattle. The evidence then leads us to conclude that such differences as are commonly seen between human and bovine tuberculosis are in no sense essential.

Bacteriologic Evidence. Morphology and Cultural Characteristics of Human and Bovine Tubercle Bacilli.—That there were certain differences to be observed in cultures of the tubercle bacillus isolated from man and from cattle was shown by Dr. Theobald Smith in 1896, who confirmed his first observations in 1898, his human cultures being almost always obtained from sputum. A study similar to Dr. Smith's has been carried on at the laboratory of the State Live Stock Sanitary Board of Pennsylvania for several years, the material for the cultures being obtained from divers sources. With one exception, which was isolated from sputum, all the human cultures have been obtained from internal organs, especially the lungs and mesenteric glands. Two of the bovine cultures have been found in milk, the others coming from internal organs or glands. The result of our observations, which have agreed closely with those of Dr. Smith, is as follows: The morphology of the bacilli in cultures of bovine origin is more uniform and constant than in cultures from man. The bovine bacilli are thick, straight, and short, seldom more than two inches in length, and averaging less. In the early generations many individuals are seen which are oval, their length not more than double their breadth. They stain evenly and deeply with carbol-fuchsin, beading being almost always absent from young cultures and often from old ones.

The human bacilli are, as a rule, much longer from the start, and tend to increase in length at once in sub-cultures. They are generally more or less curved, some cultures showing S shaped forms. They stain less intensely with carbol-fuchsin, and beading is generally seen, even in early growths.

The above characteristics are most marked and most persistent in cultures grown on blood-serum. On glycerin agar, glycerin bouillon, and glycerin potato the bacilli from the two sources approach each other in cultural features and morphology much more closely, and by continued cultivation the differences tend to become obliterated. Bovine cultures are more difficult to isolate than human, are apt to grow as discrete colonies in the first culture, and for several

generations are likely to grow in an exceedingly thin layer which resembles ground glass closely. The optimum temperature as well as the thermal death-point are practically the same.

The human bacillus, as a rule, grows more easily and abundantly from the first, and will grow well on glycerin agar in sub-cultures made directly from the original growth on blood-serum. All attempts to obtain a like result with the bovine organisms have failed.

The morphologic distinctions tend to disappear also in the tissues of susceptible animals. We may inoculate a typical bovine culture, and in a very short time scrapsigs from the various organs will show long and very much beaded bacilli.

The most striking dissimilarity is, however, seen in the action of the bacilli from the two sources on animals. By whatever method of inoculation, the bovine bacillus, as a rule, possesses a very much greater pathogenic power than the human bacillus for all animals on which it has been tried, the only exceptions being possibly those animals, like guinea-pigs and swine, which are so extremely susceptible to both types that it is hard to draw any distinction between them. This was the case with swine inoculated by feeding in our own experiments, but Koch and Schütz found that for swine also the bovine bacillus was much more active. The list of animals for which this increased virulence has been proven includes horses, cows, asses, sheep, goats, dogs, cats, rabbits, guinea-pigs, and recently the same thing has been shown to hold true for man's relative, the monkey, by de Joung de Schweinitz and Schroeder, and ourselves.

In our own experiments two monkeys inoculated subcutaneously with Culture L, obtained from milk, died on the thirty-seventh and thirty-third days, while the corresponding pair of the same species, and as nearly the same weight as possible, inoculated with Culture M, from human sputum, lived fifty-four and ninety-six days, respectively, the last being chloroformed in a moribund condition. Two other monkeys which were inoculated by feeding five times with the same cultures smeared on banana, lived forty-two and ninety days, respectively. The postmortem examinations showed for the animals which received the bovine cultures a more active invasion and more acute process.

What has been said concerning the greater pathogenic power of the bovine organism has, I think, been proven beyond question to be the rule. It must be borne in mind, however, that what we speak of as virulence is a very variable quantity, no micro-organism being known which always shows the same degree of pathogenicity. The tubercle bacillus isolated from cattle varies in its pathogenic power considerably, though not perhaps to such an extent as those obtained from human sources. Among the latter we find some cultures which

have feeble action even on the most susceptible animals, like guinea-pigs,[25] while others are most actively virulent. Besides Culture BB, described in this paper, cultures of exalted virulence have been isolated from man by Vagades and Lartigau. Whether or not these cultures were in reality the bovine organism which had infected man we cannot say now. At present our knowledge is so restricted in the matter of differentiation that we must designate the cultures human or bovine according as they are isolated from man or from cattle. The dictum of Koch that inoculation of cattle will infallibly distinguish one from the other cannot be accepted offhand, as it is far from proven that virulence for cattle is a fixed and constant characteristic. Prof. McFadyean says: "If a low degree of virulence for cattle is to be taken as the distinguishing feature of human bacilli there will be no difficulty in proving that human disease is sometimes transmitted to the lower animals."

Has the Bovine Tubercle Bacillus more Pathogenic power for Man than the Human Bacillus?—In trying to interpret the results obtained by inoculation of animals we are forced to ask ourselves whether or not they are applicable to man also? Having proven that for practically all experimental animals the bovine tubercle bacillus possesses, as a rule, a much greater pathogenic activity than the human, is it fair to conclude that this increase of virulence will hold good for man also? Until the contrary is proven, or until good reason for believing the contrary is shown, I feel that this must be our conclusion. This matter opens up a most fascinating field for speculation, in which we meet with many apparent contradictions; and until we gain a better understanding of immunity in general we cannot speak dogmatically, but must stick to ascertained facts in each individual case. Virulence is a factor which is relative to the subject, and exaltation of virulence for one species of animal does not necessarily prove an increased power for other species. Indeed, the reverse is sometimes true. For example, the strptococcus is said to become increased in virulence for mice by successive passages through these animals, but less virulent for rabbits. So, too, the bacillus of "rouget du porc," though but slightly pathogenic for rabbits, rapidly acquires a high degree of virulence for them by successive passages; but when this has taken place we find that all virulence for swine, from which it came in the first place, has disappeared. Large doses do not even make them ill.

Admitting freely all these facts, we must regard them as exceptional, for it is a firmly established rule in bacteriology that when the virulence of a pathogenic organism is increased for one animal it is increased for all that are naturally susceptible to its action as well as for those in which the disease is known only experimentally.

That as regards man a result analogous to that seen in the streptococcus, or the bacillus of "rouget du proc," has not taken place by the residence of the tubercle bacillus in the tissues of cattle is proven by the cases of accidental inoculation of man with the bovine bacillus as well as by the cases observed clinically in which tuberculosis has followed the consumption of tuberculous milk. The tubercle bacillus is unique in the extent of its pathogenic activity, both by direct experimental inoculation as well as by infection under what may be considered more or less natural conditions. The list of animals in which tuberculosis occurs in parks and zoological gardens is appalling, the discoveries of Dubard and others showing that not even the cold-blooded animals are exempt from this universal scourge. While it may be said of the tubercle bacillus that in cultures in the laboratory it is unusually tenacious of its characteristics, it is certain that in nature it has a wide range of adaptability as a pathogenic agent. Hence, for the tubercle bacillus, perhaps, more than for any other known microbe, we are justified in believing that an exaltation of virulence for practically all experimental animals will hold good in the case of man also.

Accidental Inoculation of Man with the Bovine Tubercle Bacillus.—While we cannot determine the virulence of the bovine tubercle bacillus for man by direct inoculation, we are, nevertheless, not without some information on this point, owing to the accidental inoculations observed from time to time. Four such cases have been reported to this Society, accompanied in three instances by the exhibition of the specimens.

Similar cases have been reported by Tscherning and Pfeiffer, the latter ending in general infection and death.

Dr. M. B. Hartzell has also observed two cases in which the bovine origin of the infection was not absolutely proven, though certainly highly probable, both occurring in healthy men who were employed by one of our large railways to clean and repair cattle cars. In both a well-marked tuberculosis of the skin of the verrucous type followed slight wounds of the back of the hand inflicted by broken timbers. One man recovered under local treatment, but the other died after about a year through involvement of the lungs and other organs. This patient was a robust man, aged forty-four years, weighing 175 pounds, with good personal and family histories. Dr. Hartzell felt that he was able to exclude with reasonable certainty any other source of infection. The death of Mr. Thomas Wally, Principal of the Royal Veterinary College, of Edinburg, is also attributed to infection gaining entrance through a wound received while making an autopsy on a tuberculous cow.

The interest which has been aroused by Professor Koch's paper has brought out numerous reports of such cases, which are now being published to show that man has something to fear from bovine tuberculosis.

Dr. Kurt Mueller, a surgeon of Erfort, describes the cases of two healthy young men who were under his care. Both were butchers, and in both cuts were sustained while working on tuberculous cattle, the wound opening the synovial sheath of a tendon in the hand. In each case an operation was necessary, and it was found that the wall of the sheath, as well as the tendon itself, was thickened, while upon them were large numbers of yellow nodules, proven to be tubercles by microscopic examination. These tubercles were placed very thickly near the scar, gradually becoming fewer as the scar was left. In one of the men the trouble extended from the finger to the forarm, and there was some evidence of tuberculosis even at the muscular attachment of the tendon. In the second case the tendon was attached to the sheath, and the disease limited to an area 10 cm. in length. Examination of the removed tissue proved the presence of tubercle bacilli. Both of these men had good family histories, and were free from tuberculosis elsewhere, so that Dr. Mueller has no doubt that they were inoculated with bovine tubercle bacilli.

De Jong observed the case of a man who injured his finger while examining the mesentery of a tuberculous cow. The wound did not heal, the edges became indurated, and considerable swelling ensued, with pain which increased steadily and failed to yield to ordinary treatment. Curettage and cautery were finally used with success. In the scrapings tubercle bacilli were demonstrated.

In Berlin two men who are employed in the slaughter-house to carry the condemned tuberculous meat to the place where it is destroyed have developed tuberculosis of the skin of the hands. At a recent meeting of the Medical Society, of Berlin, Professor Lassar presented cases of verrucous tuberculosis of the skin. He had observed this type of skin tuberculosis in butchers who had handled tuberculous meat. Of thirty-four cases seen by him four were in butchers; while, on the contrary, among those affected with other forms of tuberculosis localized to the skin of the hands, none belonged to this calling. Liebreich agreed with the view taken, and said he had been able to assure himself that verrucous tuberculosis of the skin was much more common among those whose duties require handling tuberculosis meats than among others. Blaschko spoke of the case of a cook seen by him in whom a tuberculous lesion followed the prick of a piece of bone.

It is interesting to note that Dr. Hartzell's two cases were both of the verrucous variety, the origin in both having been almost certainly bovine.

Drs. Joseph and Trautmann report three cases of verrucous tuberculosis of the skin occurring among employes of the municipal abattoir in Berlin, who worked exclusively with tuberculous animals.

Case I.—J. G., aged forty-five years. Was never ill before, and no tuberculosis in his family. His duties were to cut up tubercular and condemned carcasses. In 1892 or 1893 he received a small wound of the middle finger of the left hand, and a nodule soon formed, surrounded by a zone of redness. It increased slowly until 1897 or 1898, when the thermocautery was resorted to with partial success. About a year ago the man tore the first finger of the same hand on a bone from a tubercular cow. The wound cicatrized in about eight days, but later a nodule developed on the site. When examined, in August, 1891, the disease was confined to the first and middle fingers of the left hand. On the first finger nodules about the size of a pea protruded from the surface 1 mm. to 2 mm., moderately read, and having in the center a broken area covered with small crusts. The nodule on the middle finger was much larger and the verrucose condition more developed.

Case II.—J. O., aged thirty-five years. No history of tuberculosis in family. The patient, his wife, and three children had always been healthy. Has been employed in the abattoir for one year, and always in division reserved for tuberculous animals. Three months before he had suffered a wound of two fingers, following which the disease developed. On the little finger is a hard, rough, thickened area, extending entirely through the skin. On one side is an ulcer which goes deep into the corium.

Case III.—K. S., aged thirty-eight years. Employed in handling tubercular material. He showed a typical tuberculosis of the skin. As the case was being treated by another physician, the details are not given.

It would seem that instances of infection through wounds are not as uncommon as has been supposed heretofore. Their value has been questioned on the ground that inoculations do not always correspond to natural infections. I do not pretend that such cases settle the whole question definitely, but they do prove beyond question that there is no peculiar quality in the tissues of man which makes him an unfit soil for the bovine tubercle bacillus. Furthermore, they afford us means of comparison with similar cases in which the invading organism is of human origin, wounds of the hand while operating on tuberculous cadavers, or in cleaning cuspidors used by phthisical persons, being not uncommon. I have been at some pains to study the reports of such infections, and feel bound to conclude that the bovine

bacillus is at least as virulent as the human for man when introduced in such manner. We know from experimental as well as clinical evidence that the skin is the tissue most unfavorable to the growth of the tubercle bacillus. If, then, the bovine bacillus can successfully invade the skin and multiply there, with the production of characteristic changes, it seems we are fully justified in believing that organs and tissues that are known to offer favorable soil to the human bacillus will also prove favorable to the bovine organisms. On the other hand, I know of no animal which is susceptible to the human bacillus yet immune to the bovine. Birds are equally refractory to both, a small proportion of those inoculated or fed with either succumbing to tuberculosis.

Tuberculous Infection Through Food.—Koch bases his opinion as to the non-transmissibility of bovine tuberculosis to man largely on the alleged rarity of primary intestinal tuberculosis. He says: "If the bacilli of bovine tuberculosis were able to infect human beings many cases of tuberculosis caused by the consumption of aliments containing tubercle bacilli could not but occur among the inhabitants of great cities, especially children." "That a case of tuberculosis has been caused by aliments can be assumed with certainty only when the intestine suffers first—i. e., when a so-called primary tuberculosis of the intestine is found." He says that he has seen only two such cases; that at the Charité Hospital, in Berlin only ten cases were seen in five years; that among 933 cases of tuberculosis in children at the Emperor and Empress Frederick's Hospital for Children, Bagiosky never found tuberculosis of the intestine without simultaneous disease of the lungs and bronchial glands; that Biedert found only sixteen cases of primary intestinal tuberculosis among 3,104 children examined post mortem.

The assumption that the proportion of tuberculosis caused by good is correctly revealed by the lesions of the intestine or mesenteric glands is certainly erroneous, and leaves out of consideration entirely at least one very important avenue of infection.

Infection Through the Tonsils.—The numerous observations made of late years leave no doubt that the tonsils sometimes act as the port of entry for the tubrcle bacillus. As well put by Baup, "discussion is only possible as to the greater or less frequency of these lesions, and their pathological importance," a position sustained not only by the work of other observants but by his own, in which he examined the tonsils from those cases only in which tuberculosis of the lungs was absent and other ports of entry could be excluded. Dieulafoy, by the inoculation of guinea-pigs, found tuberculosis in fifteen of ninety-six cases. Latham, who was careful to employ only the interior portions of the tonsils, in forty-five consecutive cases

of children from three months to thirteen years of age, seen at autopsy, found seven which were tuberculous. One of the most recent studies of this subject is that of Friedmann, who examined the tonsils obtained from ninety-one children at autopsy, and fifty-four cases removed by operation, all but one of the latter under five years of age. Of the ninety-one cases, in three there was tuberculosis, probably not primary; in five there was tuberculosis, probably primary, with secondary involvement of lymphatic glands, intestine, and bone; in one the tonsile showed many tubercles, giant cells, and tubercle bacilli, the rest of the body being free; in seven (two with and five without tuberculosis in other parts of the body) the tonsils contained typical giant cells, but no bacilli could be demonstrated; in three giant cells attributed to other causes were found; in eleven, which showed extensive tuberculosis of other parts of the body, the tonsils were free, but showed scars; in four the tonsils were free, there being tuberculosis of the internal organs; in three bacilli were demonstrated in smear preparations, though no tubercles were found. In the remaining fifty-four cases tuberculosis was not found in any part of the body. Only one of the operative cases showed primary tuberculosis.

When we remember the frequency with which children are fed, and the ease with which particles of food lodge in the tonsils, we cannot but think that Friedmann is reasonable in his conclusion that tuberculosis of the tonsils is quite common in children, and that the infection takes place directly from food, and not through the lymph, blood, or by inhalation.

Numerous authors who have studied this question give corroborative facts, lack of time preventing further citations. Those given are sufficient, I think, to show the fallacy of looking exclusively to the intestine for the proof of a food infection. I beg to call attention to the specimen showing ulceration of the tonsils which I have here, taken from one of four pigs which were infected by feeding, ten meals containing pure cultures of tubercle bacilli being given. All the animals contracted general tuberculosis, most marked in the lungs, and ending in death. Three of the four presented lesions of the tonsils similar to those shown, while in only one could any lesion of the intestine be found. In the tonsils of the fourth pig, which showed no macroscopic lesions, many tubercle bacilli and areas of caseation were found. In three of the four pigs the cervical and mediastinal glands were markedly involved, and tubercle bacilli were readily demonstrated in smear preparations made from the cut surface of the salivary glands in the remaining one.

A similar observation was made by Koch, who, however, seems to have entirely overlooked the importance of it. He says: "These animals had without exception severe tuberculous disease, especially

tuberculous infiltration of the greatly enlarged glands of the neck and of the mesenteric glands, and also extensive tuberculosis of the lungs and spleen."

Clinical Observation.—The number of cases in which infection can be traced to the consumption of tuberculous milk is not large, and almost all of them are open to some criticism from the fact that all other sources of infection cannot be positively excluded. From the nature of the case this will always be true, and we can never shut children up and feed them with tuberculous milk in the way of an experiment. However, evidence in some of the cases is so clear that Nocard has well said: "It has almost the value of an experiment," and it is quite sure that we would unquestionably accept evidence of much less value if any other disease than tuberculosis were concerned.

The cases reported by Stang, Demme, Gosse, Ollivier and Law, involving nineteen persons, are too well known to need repetition here.

Ebers reports six cases, collected by several observers, of tuberculosis in children, attributed to the milk of tuberculous cows.

Bang, through inquiries in Denmark, has collected reports of nine persons in whom infection could be traced with reasonable certainty to milk from tuberculous cows.

Von Ruck reports the case of a father and child which are very convincing, and says that he has observed several others in which there was very good reason to believe that milk was the agent of transmission for the tubercle bacillus.

Klebs and Rievel have recently reported two cases which came under the observation of the former. A healthy young man employed by Klebs to assist in making some investigations on milk infection had the habit of drinking the milk of the tuberculous cows used in the experiment. In a few months he died of miliary tuberculosis. The second case was one of six male children, who died at the age of two years of tuberculosis of the cord and meninges. This child was the only one of the six fed on cow's milk and the only one that developed tuberculosis.

Postmortem Evidence.—The reports of pathologists based on autopsies prove conclusively that in a certain proportion of persons dying of tuberculosis, and especially in children, the infection takes place through the intestine. As to the frequency of infection by this route there is a wide divergence of opinion, due partly, no doubt, to the fact that this method of infection is much more common in some localities than others, owing to local conditions, and partly to the interpretation given to the postmortem findings. Our method of determining the portal of entry is not entirely satisfactory, as is shown by the large number of cases reported by many pathologists in which it is impossible to locate the primary lesion.

In general the determination of the primary lesion is based on the belief that the lymphatic glands in children give evidence of the duration and extent of tuberculous diseases in the organs with which they are in relation. Consequently if the bronchial glands show more advanced caseation than the mesenteric the infection is put down as being through the respiratory tract. The fallacy of this has, I think, been demonstrated as regards infection through the tonsils, and that it is correct, even when the absorption takes place through the intestinal mucosa is open to question. During intestinal digestion there is a constant current from the intestine to the mesenteric glands, and thence up the thoracic duct into the venous circulation. Any tubercle bacilli which may have gained entrance into the stream are carried almost immediately into the lung, and deposited there by election.

It has been shown by Dobroklonski, working under Cornil, that the tubercle bacillus can penetrate the wall of the intestine in the absence of any demonstrable lesion, and that the contact does not need to be prolonged. As the result of carefully conducted experiments on animals he says: "Tuberculosis can certainly invade the body through the digestive tract. For this invasion to occur it is not necessary that there should be either a lesion of the intestinal wall, a desquamation of the epithelium, or any local modification whatever, or an anterior inflammatory process. The tuberculous virus (bacilli as well as spores) can easily pass through the epithelial lining of the intestine when it is entirely normal. This penetration is particularly easy at those points where the contact of the virus with the intestinal wall is prolonged, but it is not necessary that there should be prolonged contact or that it should be any longer than what occurs normally."

In our work at the laboratory of the State Live Stock Sanitary Board we have often been struck by the extensive involvement of the lungs in animals infected by feeding, and the slight injury of the intestines. Indeed, in some animals it has been impossible to detect any involvement of the intestines at all.

I ask your attention to specimens from two animals illustrating these points. The first is from a cow (No. 26435) which was fed with bovine tuberculous material. Both lungs were involved and had cavities in them. The bronchial glands were enlarged, and showed small nodules. The mediastinal glands were enlarged and softened, but showed no nodules. The mesenteric glands were normal, and no lesion of the intestinal wall could be found.

The second is from a monkey fed with a pure culture obtained from the mesenteric gland of a child (Culture BB). Both lungs are involved throughout and to a much greater extent than the abdominal organs. The bronchial glands are enlarged and caseous.

In the intestine only one point of injury can be found, and most of the mesenteric glands are normal in size, and show a few nodules 1 mm. in diameter. The glands associated with the upper intestine are much enlarged and show caseation, though not more advanced than what is seen in the bronchial glands.

The specimens from the monkey illustrate another important point, namely, the occurrence of coincident infection through the upper part of the digestive tract and the intestine. If this animal had been examined without the knowledge of its history it would almost certainly have been put down as one of those cases in which the avenue of infection could not be positively determined. The lungs show much more extensive disease than any of the abdominal organs, and the bronchial glands show caseation as well as some of the mesenteric, and to an equal degree. This monkey was tested with tuberculin before the experiment began, and was in perfect health when the feeding with tubercle bacilli commenced. The key to the situation lies in the enlargement and caseation of the cervical lymphatic glands, indicating an infection through the tonsils or some neighboring part of the upper digestive tract, though no lesion could be detected. We have here an undoubted food tuberculosis, yet the respiratory tract shows the chief involvement. Does not the same thing occur also in children, and more often than we suspect?

With these facts in view it seems not impossible that an infection gaining entrance through the intestines may appear first in the lung, and thus be erroneously attributed to the respiratory tract.

On one point all pathologists as well as clinicians seem to agree, that in children tuberculosis shows a marked tendency to become generalized, and this occurs with such rapidity that it is often impossible to decide where the infection gained entrance.

The postmortem statistics are gathered mainly from hospitals and asylums for children, and it is in children that we have most reason to fear infection by food, their diet consisting as it does so largely of cow's milk. The tremendous mortality of children from tuberculosis has forced us to pay particular attention to the study of the factors at work in early life, and a number of interesting and valuable analysis of autopsy records have been published. From England we get the most positive evidence of infection through the intestine, and the most striking proofs of its frequency. English pathologists are practically unanimous in regarding the intestine as a frequent path of infection, the primary lesion being associated with this tract in about 25 per cent. of all cases. We may examine the figures given by some of the more recent writers on this point.

Carr, examined 120 cases at the Victoria Hospital for Children, London. Of these in eighty-two the disease was generalized, in the

sense that the lesions in different localities seemed to have a "common simultaneous origin from some infective centre, or else that there were several quite independent tuberculous centers in different parts of the body." In seventy-nine cases the primary lesion was in the lung or bronchial glands; in twenty cases in the intestine or mesenteric glands; in six cases it was impossible to tell whether the respiratory or the digestive tract was first involved; in eleven cases widely separated caseous foci were found, and the primary lesion could not be located; in four cases no centers could be found, the lesions being generalized.

Guthrie, at the Children's Hospital, Paddington, London, examined seventy-seven cases. He considered that in forty-two cases, or 54.5 per cent., the primary lesion was in the respiratory tract; in nineteen cases, or 24.6 per cent., it was in the intestinal tract. Of the remaining sixteen cases the thoracic and abdominal organs were equally affected in seven; in six the original was unknown, and in three otherwise accounted for. In only thirty-two cases could the origin of the tuberculosis be traced with certainty to the glands, to the thoracic seventen times, and the mesenteric fifteen times.

Still, at the Great Ormond Street Hospital for Children, in 769 consecutive autopsies on children under twelve years of age, found 269 cases which showed tuberculous lesions. Of these 117 or 43.5 per cent., were children under two years of age; and 56.5 per cent. —more than half the total number—were children under three years of age. The origin of the disease was as follows:

Lung,	105	138=51.3 per ct.
Probably lung,	33	
Intestine,	53	63=23.4 per ct.
Probably intestine,	10	
Ear,	9	15= 5.5 per ct.
Probably ear,	6	
Bones and joints,	5	53=19.8 per ct.
Fauces,	2	
Uncertain,	46	

In forty-three cases in which death was due to other causes, such as diphtheria, heart disease, etc., the primary focus of infection could be determined with great certainty, as the tuberculosis had not become generalized. Among these the primary lesion was respiratory in twenty-six cases, or 60.4 per cent.; intestinal in sixteen, or 37.8 per cent.; and in the year three times.

Dr. Shennan, of the Royal Hospital for Sick Children, in Edinburgh, found among 278 cases of tuberculosis 28.1 per cent. in which infection had taken place by the intestinal tract, showing that the high percentage in which this route of infection is observed is not confined to London, where it might be supposed that conditions were such as to favor it specially.

The few reports we have from America indicate that infection through the intestine is much less frequent than in England.

Northrup reports that among 125 autopsies, in only three was the primary lesion found in the intestinal tract. In thirty-four cases, however, the disease was so general and far advanced that he was unable to determine the mode of invasion.

Holt among 119 tuberculous children examined postmortem found the intestines affected forty times and mesenteric glands thirty-eight times, but in no case did he consider the intestine as the route of invasion.

Bovaird, in 1899, published the records of seventy-five autopsies on tuberculous children. In sixty cases infection had taken place through the respiratory tract; in eight the bronchial and mesenteric glands were equally involved, and in seven the records were incomplete. He has recently added the record of fifty cases, among which two cases of primary intestinal infection occurred. The num ber of indeterminate cases is not given.

German statistics, as far as I have been able to obtain them, do not sustain Koch's position, although they indicate that primary intestinal tuberculosis is not so common in that country as in England, which we would hardly expect, considering the precautions prescribed in Germany and the lack of regulations in England.

However, intestinal involvement in children appears to be quite frequent in most parts of Germany; and as many of the reports do not clearly indicate the primary seat of invasion, we are justified in believing that a fair proportion of these cases are due to intestinal infection. For example, the statement given by Koch and attributed to Baginsky—that among 933 cases of tuberculosis in children he never found tuberculosis of the intestine without simultaneous disease of the lungs and bronchial glands—is entirely indefinite as to the primary seat of the disease, and as quoted furnishes no ground whatever for Koch to stand on.

Against the figures given by Koch—which are confined to his own experience—the reports of Baginsky, and a series of cases attributed to Biedert, we have the statement of Professor Hueppe that "the number of these cases (primary intestinal tuberculosis) occurring in children is by no means so small as Koch alleged. The number of cases may be fairly reckoned as between 25 and 35 per cent. of all deaths of children from tuberculosis."

Among fourteen children who died from other diseases, and in whom the existence of tuberculosis was not recognized before death Kossel found tuberculosis of the bronchial glands ten times and of the mesenteric glands four times. In twenty-two children who died of tuberculosis he found the disease confined to the intestinal tract in only one case.

It is unnecessary to quote further statistics on this point. The extent of intestinal tuberculosis varies in different countries and in different parts of the same country—a fact which of itself indicates a local factor, such as the greater or less prevalence of tuberculosis in cattle. One cannot study such statistics as those given without being fully convinced that a very important proportion of the children who die of tuberculosis are infected through their food, and that the report made to the council of the British Medical Association was justified, namely, that "the mortality from tuberculosis in early childhood is not decreasing as it is at other ages in the United Kingdom; and the opinion that this great prevalence of the disease in childhood is due to infection through the alimentary canal by milk from tuberculous cows appears to be well founded."

Extent of Tuberculosis in Cattle.—It is well known and so universally acknowledged that tuberculosis is a wide-spread scourge in cattle that it would be superfluous to give an array of figures showing the extent of its ravages in various countries. Those interested in this phase of the subject will find the latest statistics given by Dr. Leonard Pearson, in Bulletin No. 75, issued by the Commonwealth of Pennsylvania, Department of Agriculture. In studying such statistics it must be borne in mind that it is in the milch cow, and especially the cow on the dairy farms near large cities, that is most apt to fall a victim to tuberculosis. In Pennsylvania, Dr. Pearson has found that of the tubercular herds tested about 13 per cent. of the animals had tuberculosis. Some herds show a very high proportion of diseased animals. Thus, for example:

Among 174 cattle,	166 were tubercular.
73 cattle,	59 were tubercular.
22 cattle,	17 were tubercular.
14 cattle,	14 were tubercular.
20 cattle,	20 were tubercular.
59 cattle,	53 were tubercular.

In other parts of the State tuberculosis is very rare or even unknown. These places are found in the interior counties, where the stock is "native" for the most part, or were stocked at a time when bovine tuberculosis was very little known in the United States.

There has been and is considerable discussion as to the stage of the disease at which a tuberculous cow becomes dangerous through the passage of tubercle bacilli into her milk. Some authorities hold that there must be actual disease of the udder for this to occur, while others believe that this is not necessary. As early as 1893 Dr. Theobald Smith showed that the tubercle bacillus may be found in the milk of tuberculous cows when the udder, so far as the naked eye could tell, was free from disease. In a series of experiments at the laboratory of the State Live Stock Sanitary Board of Pennsylvania

the mixed milk of five cows was examined by intraperitoneal inoculation of guinea-pigs. These cows had reacted to tuberculin, but were in good condition and of fine appearance. Repeated examinations of the udders by several veterinarians failed to reveal any lesion, and examination after the death of the animals gave the same negative results. No attempt was made to concentrate the bacilli; on the contrary, the whole quantity of milk was well shaken, in order to imitate as nearly as possible natural conditions, and moderate doses of milk (10 c. c.) were used. Of eighty-eight guinea-pigs employed in this test sixty-three lived long enough for the development of tuberculosis, and of these ten, or 15.8 per cent., became tubercular.

More surprising and more unusual are the results of Rabinowitsch and Kempner, who inoculated the milk of fifteen cows into guinea-pigs, the experiment being made to determine whether or not the milk of cows having a tuberculosis which could be detected only by tuberculin, and not by physical examination, might be virulent. Three examinations were made by a veterinarian in the course of the experiment. Of the fifteen animals ten were found to give virulent milk, a percentage of 66.6. One cow gave milk which contained a yellowish, gelatinous material, and caused a fatal peritonitis in a l animals inoculated. Leaving this out, the positive results amount to 71.4 per cent. All of the cows had reacted to tuberculin, but none showed clinical evidence of udder disease when the experiment began. Of the ten giving virulent milk three showed advanced general tuberculosis, but no disease of the udder; two showed no evidence of disease at al', and one only on the second and third examinations. One cow had rales at the time of first examination, but these disappeared, and she showed no evidence of disease after. On post-mortem one cow was found to have tuberculosis of the udder, and one showed clinical evidence of it on the third examination, made six months after the experiment was begun. The authors conclude: "Milk may contain tubercle bacilli, first, in beginning tuberculosis, without discoverable disease of the udder, and, second, in latent tuberculosis that can be detected only by the tuberculin reaction;" also, "milk from cows that react to tuberculin must be suspected of being infectious in every case."

With thes results before us we must admit that while tuberculosis of the udder is the most dangerous condition, we cannot by any means regard the milk of cows with general tuberculosis, but the udders of which are free from the disease, as being safe for food. We must insist that danger is not limited to those herds which 'arbor one or more cows with udder tuberculosis. I cannot agree with those writers who attempt to belittle the dangers to which milk-fed babies are exposed by pointing out the comparative infre-

quency of tuberculosis of the udder. Dilution with the milk of other cows free from tuberculosis no doubt lessens the danger, but does not remove it.

Acid-fast Bacilli.—A few years ago Möller announced the discovery of a bacillus having the morphology and staining reactions of the tubercle bacillus. He has shown that this bacillus and others closely allied to it may constantly be found in forage and in the feces of animals fed on such forage. Petri, Rabinowitsch, Grassberger, Korn, and others have found the same or like bacilli in milk, butter, and margarine; Rabinowitsch has isolated one of the same group from a case of gangrene of the lung in man; Karlinsky has shown their presence in nasal mucus, and Marpman has found them in urine, so that we know that this group of "acid-fast" bacilli has a wide distribution in nature. The property of resisting decolorization by mineral acids was for a long time considered diagnostic of the tubercle bacillus. The discovery, therefore, of a comparatively large group of organisms having the same property, and being indistinguishable morphologically under the microscope, has served to throw some doubt on researches in which the microscope has been relied on entirely to demonstrate the presence of the tubercle bacillus in milk. Animals such as guinea-pigs and rabbits inoculated intraperitoneally with cultures of these bacilli, or with milk, butter, etc., containing them, develop nodules which may sometimes be mistaken for tuberculosis. However, such mistakes must be rare, and there can be no doubt that the true tubercle bacillus passes into the milk of tubercular cows, as shown above. Reinoculation, microscopic examination of the tissues, and the isolation of cultures can be relied upon to clear up the diagnosis of any doubtful cases.

Solution of the Problem.—In the solution of the problem before us the most directly valuable data will, I think, be obtained from the examination of cultures isolated from the abdominal organs of children in whom there is reasonable evidence of infection by the intestinal tract. When these cultures are found to have a high degree of pathogenic power, and are able to infect cattle in moderate doses, we will be justified in saying that the children from whom they were obtained were infected in the first instance from bovine sources. By the examination of a large number of such cases we will, I believe, obtain very valuable information as to the frequency with which children are infected by milk. On the other hand I do not consider that we can entirely exclude bovine infection even in those cases where the abdominal organs yield a culture of feeble virulence, for the reason that we at present know nothing of the effect produced on the bovine bacillus by prolonged residence in the human body. It is certain that the various types of tubercle bacillus known to us have sprung from a stock common to them all, and that have acquired

their racial peculiarities by residence in different animals through which they are subjected to a difference in food, temperature, and resistance. In other words, the struggle for life is carried on in the various species of animals under varying conditions, the result being that in each animal the tubercle bacillus acquires properties which best enable it to carry on life in that particular host. The acquisition of these peculiarities no doubt requires a certain lapse of time, but how much we do not know. We have experimental evidence that it does not require a great time to change the tubercle bacillus from a higher into a lower type. By the method of inoculation in the peritoneal cavity in collodion sacs Nocard has shown that in from five to eight months both the bovine and human bacillus can be made to acquire the cultural characteristics of the avian bacillus, and to a certain extent its pathogenic action also. A few passages from fowl to fowl during four to six months increased this greatly. By passage through the blind worm Möller has in the course of a year so changed the human tubercle bacillus that it grows like the organism of fish tuberculosis, and has the same temperature reactions. It grows best at 20 degrees C., and ceases to grow entirely at 30 degrees C. The bacillus of fish tuberculosis, discovered by Dubard had for its origin the human bacillus, the fish having fed on the sputum and dejecta from a patient far advanced in phthisi. The fish had been subjected to this for about a year before the disease was noticed.

With these facts before us I do not think we are forcing a point in believing that it is at least possible for the bovine bacillus to become rapidly so changed in the body of man that it will show the cultural and pathogenic peculiarities which we find usually in cultures of human origin. For these reasons our observations should be made by preference on cases which are rapid and acute.

Conclusion.—The evidence at hand forces us to conclude that human and bovine tuberculosis are but slightly different manifestations of one and the same disease, and that they are intercommunicable. Bovine tuberculosis is, therefore, a menace to human health. We are not in a position at present to define positively the extent of this danger, but that it really exists cannot be denied. In the past there has probably been a tendency to exaggeration, but however great this may have been it does now justify any attempt at belittling the risk, and it is folly to blind ourselves to it.

The eradication of bovine tuberculosis is amply justifiable from a purely economical stand-point; viewed in its bearing on human health it becomes a public duty.

The paper below is offered here because it gives a review of the work done under the auspices of the State Live Stock Sanitary Board on the vaccination of cattle against tuberculosis. It was read before the Pathological Society of Philadelphia, November 13, 1902.

SOME EXPERIMENTS UPON THE IMMUNIZATION OF CATTLE AGAINST TUBERCULOSIS.

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When an extensively tubercular herd is tested with tuberculin one usually finds some animals that do not react to the test and are free from disease. These uninfected animals may be young or they may be recent additions to the herd, and their freedom from disease may be due merely to the fact that they have not had time to contract it; on the other hand, they are often cows that have been members of the herd and exposed to infection for years. That the freedom of these cattle that have long resisted the disease is not due to breed or family immunity has, in numerous instances, been shown by the fact that their parents or offspring have succumbed to tuberculosis.

To what is such resistance to tuberculosis due? It is evident that it does not depend upon species, breed, or lack of exposure. It is an individual factor. An animal may possess some power within itself to resist the tubercle bacilli that it is constantly exposed to and must daily inhale and ingest.

Careful observation of these cattle and study of them in series show that the immunity they possess is not due to what is roughly termed good general health or what the stockman knows as good condition. Cattle resistant to tuberculosis may suffer with some other disease or be in a bad state of nutrition. Cattle that contract tuberculosis show, in very many instances, until the infection is well advanced, the usual signs of good health, such as soft coat, pliable skin, clear eyes, good appetite, and regular growth or increase of

weight or yield of milk in proportion to the quantity and quality of food consumed. It appears, then, that there is reason to believe that some cattle have a specific resistance to tuberculosis. We know that specific resistance or immunity of the individual, occurring under natural conditions, usually depends on a previous attack of the disease against which the animal is immune, or, as in the case of Texas fever, upon the continued existence of the disease in a form so mild as not to appreciably disturb the various functions. This principle receives practical application when persons are rendered immune to small-pox or animals to anthrax, black-quarter, lung plague, rabies, or Texas fever by inoculating them with the attenuated but living virus of the respective disease, and thus causing them to develop it in a comparatively mild form, from which speedy recovery and subsequent immunity are almost certain.

From the inoculation there results the automatic development of an antitoxin that counteracts the toxin of the disease, and, at the same time, prevents or retards the growth of the organism of that disease. Until comparatively recently this principle has been thought to hold only in respect to certain acute infectious diseases, but it is now known to be of much wider application. Protection upon this principle is usually known as vaccination. In some cases the germ-free toxin is used for a similar purpose.

In 1901 we conducted an experiment for the purpose of determining the influence of Koch's original tuberculin upon the resistance of cattle to tuberculosis. In this experiment were used four cows known by the numbers 26554, 26555, 26556, and 26557. Each was tested with tuberculin before it was admitted into the experiment. Two of these cows, 26554 and 26557, were given daily injections of 5 c. c. of concentrated tuberculin for ten days, from August 24 to September 2, 1901, inclusive. Each of the four cows in the experiment was fed daily 100 grammes of hacked tuberculous lung tissue from a cow, for ten days, from the 10th to the 19th of September, inclusive. The first pair of cows, 26554 and 26557, that had received preliminary injections of tuberculin were given subcutaneously 15 c. c. of concentrated tuberculin each day during the progress of the feeding upon tuberculous material. The other two cows, 26555 and 26556, which had not received the daily preliminary injections of tuberculin, received no tuberculin during the experiment.

One of the cows (26554) that had been treated with tuberculin, and one (26555) that had not been treated with tuberculin were killed November 25, 1901. The cow (26554) that had been treated with tuberculin showed upon post-mortem examination lesions of tuberculosis in the post-pharyngeal and mesenteric lymphatic glands. The control cow (26555) showed lesions of tuberculosis in the right

lung and in the bronchial and mediastinal lymphatic glands, the post-pharyngeal and intermaxillary lymphatic glands and in the mesenteric lymphatic glands. The lesions in this control cow were more widely distributed and more advanced than in the cow that had received large quantities of tuberculin.

The other two cows of the experiment were killed December 16, 1901. In the first of these (26557) which had received the injections of tuberculin, no lesions of tuberculosis were found excepting in the mesenteric lymphatic glands. A few of these glands of both the small and large intestine showed small areas of caseation. The second control cow (26556) showed lesions of tuberculosis in both lungs, the bronchial, mediastinal and post-pharyngeal glands; and the lympatic glands of the mesentery were more extensively involved than in the preceding cow.

From this it would appear that subcutaneous injections of the toxin of the tubercle bacillus had had some influence in increasing the resistance of these two cows to feeding tuberculosis.

E. A. deSchweinitz reported in the Medical News for December 8, 1894, some experiments made by him upon guinea-pigs, in which these animals were inoculated with tubercle bacilli of human origin cultivated for about twenty generations upon glycerin beef broth, and were afterward inoculated with tuberculous material from a cow. The guinea-pigs so treated remained free from tuberculosis, while check animals inoculated with the same tuberculous material from the cow died of tuberculosis within seven weeks. De Schweinitz also showed that the twentieth generation of broth culture appeared to be incapable of producing tuberculosis in a cow when she was inoculated intravenously with a small quantity. De Schweinitz and Schroeder report (U. S. Dept. of Agr., B. A. I. Bulletin No. 13, 1896) upon other inoculations similar in nature and confirmatory of the above results. They show, further, that the attenuated culture they were working with was not virulent for cattle when inoculated intravenously in quantities of 500 c. c. of suspension in liquid.

The immunizing effect upon cattle of the administration intravenously of tuberculous material or of living cultures has been studied by J. McFadyean and by von Behring.

McFadyean reported in the Journal of Comparative Pathology and Therapeutics for June, 1901, and March, 1902, upon some experiments regarding the immunization of cattle against tuberculosis. He inoculated four cattle intravenously with emulsions of tuberculous material and cultures from various sources. One of these cattle, which had responded to the tuberculin test, and was, no doubt, tubercular upon the beginning of the experiment, was given about 150 c. c. of tuberculin in divided does before inoculation. Fifteen weeks after inoculation this animal was killed and was found to contain but one

tubercle, the size of a pea and completely calcified, in a mesenteric gland. Two control cattle inoculated with an equal dose of the same material died of generalized tuberculosis. Of the other three cattle of the series one was tubercular at the beginning of the experiment. All of these were inoculated intravenously from seven to eleven times during a period of from two to three years with emulsions of tuberculous materials and with cultures from various sources. It is interesting to note that the first inoculation upon each of the cows that was free from tuberculosis at the beginning of the experiment was made with avian material which was probably of very low virulence for cattle. The cattle so inoculated died of tuberculosis after two to three years from the beginning of the experiment, and in each case the chief lesions were in the kidneys and the brain or its covering membranes. The cerebral lesion appears to have been the immediate cause of death in each instance. There can be no doubt that thes animals were remarkably resistant to tuberculosis, because they lived for months or years after repeated inoculations with large quantities of material of proven virulence for cattle.

Von Behring announced December 12, 1901, that he was engaged in studying the immunization of cattle against tuberculosis, and he has since published a report (Beiträge zur Experimentellen Therapie, Heft 5, 1902) upon his work. He details experiments upon several cattle treated with injections of tuberculin and with cultures of varying degrees of virulence and from several sources, and also inoculated with tuberculous material or cultures of proven virulence. It may be noted that a pure culture virulent for cattle was not available for use in von Behring's work until 1901. The experiments upon seven cows specially reported were commenced between July and December, 1901. These cows have all received repeated injections of tuberculin and of tubercle virus of low and high virulence. All of the protected cows are still alive excepting one that was killed and was found to have numerous tubercular nodules in the lungs, although these were believed to be retrogressive. This general experiment cannot be looked upon as finished, and any report upon it must be regarded as incomplete until the cows die or are killed and are examined post-mortem. The cows may appear to be in good health now, but notwithstanding, they may be extensively tubercular. However, that they are alive after receiving quantities of virulent tuberculous material that are sufficient to kill untreated cows shows that they have extraordinary resistance to tuberculosis. The method used to treat these cows was not systematic nor the one that he now recommends upon the evidence of experiments not yet published. The method now recommended by him is to inject intra-

venously 0.001 gramme of a scraping from a serum culture of tubercle bacilli dried in vacuum, powdered, and suspended in water. The culture used for this purpose was obtained originally from human sputum and has been grown in his laboratory since 1895. After four weeks a second injection is made containing twenty-five times the original quantity of tubercle bacilli, or 0.025 gramme. Von Behring has now underway extensive experiments planned to test the resistance of immunized calves to natural infection from association with infected animals in contaminated premises.

Since 1896 tuberculosis of cattle has been the subject of special and extensive study and experimentation in the laboratory and research station of the Pennsylvania State Live Stock Sanitary Board. During this time the virulence for cattle and other animals of tubercle culture and material from many sources have been tested by Dr. M. P. Ravenel, Dr. John J. Repp, and ourselves. The results of some of this work have been reported upon several occasions to this Society by Dr. Ravenel and to the British Congress on Tuberculosis in 1901. Some experiments looking toward the development of better methods for repressing tuberculosis in herds have been reported by Dr. Leonard Pearson.

It has been shown by numerous experiments that the sputum of persons suffering from consumption and cultures of tubercle bacilli made from such sputum are usually comparatively non-virulent for cattle. It is important to know, further, that a given culture of sputum tubercle bacilli is incapable of producing serious disease in such quantities as it may be necessary to use in an attempt to increase an animal's resistance to tuberculosis.

The following experiment throws light upon the question as to the quantity of culture of this kind that may be administered and the effect of repeated inoculations made in four different ways. A Jersey heifer (26415) shown by tuberculin test to be free from tuberculosis was inoculated intraperitoneally September 29, 1900, with 4 c. c. of a standard suspension[1] of human sputum culture that had remained in a collodion capsule in the abdominal cavity of a bull for seven months, and was then regained in pure culture by Dr. Ravenel. The third generation on blood serum furnished the material for this inoculation. The heifer was inoculated intravenously March 15, 1901, with 13.5 c. c. of a standard suspension of tubercle bacilli, probably of human origin, that had passed through a coati (Nasua narica), and were recovered in pure culture by Dr. Theobald Smith in 1895. This culture had afterward remained about one year in a collodion capsule in the peritoneal cavity of a heifer, had been recovered by Dr. Ravenel,

1By a standard suspension is here meant a suspension of tubercle bacilli in water in such quantity as to give an opacity equal to that of a twenty-four-hour culture of typhoid bacilli in bouillon. 1 c.c. of such a suspension is estimated to contain the equivalent of 0.0013 gramme of tubercle bacilli after drying ten days in a desiccating chamber over calcium chloride.

and the third generation on blood serum after recovery supplied the material for the present inoculation. A second intravenous inoculation with 10 c. c. of similar suspension was made June 1, 1901. August 23, 1901, this heifer was inoculated with 20 c. c. of a standard suspension in water of a culture (H) of tubercle bacilli from human sputum. This quantity of material was divided into four parts of 5 c. c. each, and these parts were injected beneath the skin, into the peritoneal cavity, into the jugular vein, and into the lung, respectively. These injections were repeated at intervals of from seven to ten days until January 29, 1902. The quantity of standard suspension was increased 10 c. c. with each successive inoculation, so that at the last, the eighteenth, inoculation the total quantity given was 160 c. c. The total quantity given in this series of inoculation was 1797 c. c. of standard suspension. There was a rise of temperature of from two to four degrees following each inoculation after the first one. The first inoculation caused no temperature reaction. The heifer was in strong, thrifty condition at the completion of the series of inoculations, and improved in condition throughout the following months. It was killed August 14, 1902. The condition was good, and there was an abundance of fat upon the carcass and about the intestines. The post-mortem examination revealed the lungs to be normal in color and elastic; they were free from nodules, but were attached to the chest walls along the lower borders by fibrous bands. A few flakes of fibrin were found upon the omentum, and these flakes contained a few calcareous nodules about one-twelfth of an inch in diameter. The liver was adherent to the diaphragan over an area five inches in diameter.

A yearling grade short-horn bull (26442) after having been tested with tuberculin and proven to be free from tuberculosis, was inoculated intraperitoneally November 19, 1900, with 16 c. c. of a suspension of tubercle bacilli from a culture from human sputum that had remained in a collodion capsule in the peritoneal cavity of a bull for seven months. The third generation on blood serum after recovery furnished the material for this inoculation. March 17, 1901, this bull was inoculated intravenously with 13.5 c. c. of a standard suspension of a culture similar to that used in the inoculation of the above heifer (26415) on March 15 and June 1, 1901. This animal was subsequently inoculated in the same manner as the heifer, receiving eighteen inoculations between August 23, 1901, and January 10, 1902. He received in all 1710 c. c. of standard suspension. He reacted following the inoculations very much as the heifer, although somewhat more slowly. He remained in good condition and apparent good health until he was killed, excepting for the development of an abscess over the jugular vein, which was opened November 22, and afterward healed nicely. January 18, 1902, this bull was

inoculated intraperitoneally with 10 c. c. of a standard suspension of tubercle bacilli from a culture (H) of bovine origin. The virulence of this culture for cattle had been proven by numerous inoculations, among which the following may be mentioned: A cow (26431) weighing 950 pounds was inoculated intravenously January 8, 1901, with 5 c. c. of a standard suspension from a culture of bovine tubercle bacilli H. The cow lost weight rapidly to 750 pounds, and died March 4, 1901. Post-mortem examination revealed most extensive miliary tuberculosis of the lungs. Another cow (26433), weighing 698 pounds, was similarly inoculated at the same time, and died January 26 of miliary tuberculosis of the lungs. This cow received two injections of tuberculin of 0.4 c. c. each on January 16th and 22d. Both of these cows had been shown to be free from tuberculosis by tuberculin test before they were inoculated. A red heifer (45072), about eight months old, was tested and did not react. It was inoculated intraperitoneally April 30, 1902, with 5 c. c. of standard suspension of bovine culture H. It died June 7, 1902, and was found to contain extensive lesions of tuberculosis upon the peritoneum and abdominal organs, and the lungs, also, were crowded with small tubercles. The bull (26442) was killed August 13, 1902. The general condition was good, and there was much fat upon the carcass and about the internal organs. The pleura lining the lower half of the chest was covered by a sheet of partly organized fibrin from one-eighth to one-third of an inch thick. The lungs themselves contained a few nodules about one-half inch in diameter surrounded by thick walls and containing caseous pus in which there were many tubercle bacilli. These nodules did not seem to be progressive, and appeared to be abscesses indicating the sites of previous inoculations. The peritoneum covering walls, the stomach, intestines, spleen, and liver was coated with a layer of partly organized fibrin, as in the chest. The lymphatic glands about the rectum were enlarged and caseous. The surface of the omentum was rough from the presence of a thin layer of partly organized fibrin. The omentum was thickened in places, but there were no distinct nodules. From the fact that the fibrinous coating of the serous membranes was as pronounced in the thoracic as in the abdominal cavity it is probable that the virulent culture of tubercle bacilli injected into the abdomen has little to do with the production of this deposit, which may readily have resulted from the discharge of a pulmonary abscess into the pleural cavity or the discharge into the peritoneal cavity of the purulent contents of one of the softened lymphatic glands in the pelvis.

It is evident that the sputum tubercle bacilli used for the inoculation of these two animals (26415 and 26442), even in the exceedingly large quantities in which they were employed, were incapable of causing general tubercular infection. Even the intraperitoneal inocula-

tion of the bull with a quantity of virulent culture nearly twice as great as was necessary when similarly administered to kill an unprotected heifer did not, so long as he was permitted to live, appreciably disturb his general health. The human sputum culture M used for these inoculations was obtained by Dr. Ravenel from the sputum of a consumptive woman in September, 1899. As a further indication of its degree of virulence, it may be noted that two guinea-pigs were inoculated, subcutaneously, December 18, 1901, each with 1 c. c. of a standard suspension of this culture. One guinea-pig died March 8 and the other March 20, of generalized tuberculosis. Two rabbits were also inoculated December 16, 1901, each with 2 c. c. of the same suspension. Both died suddenly in June, one on the 3d and the other on the 10th, from having been given improper food. Both were free from all evidence of tuberculosis and showed no alteration excepting diffuse redness of the intestines.

These experiments tend strongly to show that cattle may be refractory to enormous quantities of tubercle bacilli from human sputum when injected into the blood beneath the skin, into the peritoneal cavity or into the lungs; and the result upon one of the animals (the bull) indicates that after such treatment the resistance to virulent culture of bovine origin may be increased.

An experiment was inaugurated in March of this year, to again, and more definitely, test the immunizing value of repeated intravenous inoculations of cultures of sputum tubercle bacilli not virulent for cattle. For the purpose of this experiment four young cattle were used, as follows: A black and white bull, sixteen months old (46066); a red heifer, twelve months old (45068); a red heifer, fifteen months old (45067), and a red heifer, eleven months old (45071). All were tested with tuberculin and were proven to be free from tuberculosis. They were divided into two groups of two each as nearly equal as possible in respect to age, size, and general condition. The animals of one group were inoculated intravenously seven times between March 24th, and June 2, with gradually increasing quantities of from 10 c. c. to 25 c. c. of a standard suspension of a culture of sputum tubercle bacilli. In all, 125 c. c. of this suspension were administered, representing about 0.16 gramme of tubercle bacilli.

Each of the four animals in this experiment—the two that had been vaccinated (45066 and 45068) and the two kept as controls (45067 and 45071)—was inoculated July 29th by injecting into the trachea 10 c. c. of a standard suspension of bovine tubercle bacilli (culture H) known to be virulent for cattle. The intratracheal method of inoculation was used, because it furnished a means of conveying tubercle bacilli into the organs most frequently infected in nature and in a manner unattended by disturbance of function or with material

traumatism. It seemed to give a mode of infection closely resembling the natural one. One of the vaccinated cattle (45068) was killed October 4th. A searching post-mortem examination revealed all of the organs, including their lymphatic glands and covering membranes, to be free from all evidence of disease, with the exception of a slight fibrous thickening of the wall of the jugular vein at the point of vaccination. At the site of the intratracheal inoculation of July 29th there was no mark, and the mucous membrane lining the trachea was entirely normal.

A control heifer (45071) killed October 8th showed the following upon post-mortem examination: At the point of inoculation, upon the outside of the trachea and beneath the skin, there was a globular abscess about three-quarters of an inch in diameter, containing cheesy pus. The mucous membrane of the trachea showed a number of small, reddish elevations (tubercular) below the point of inoculation. The lungs were studded upon the surface and upon cross section with grayish nodules one-quarter to one-half an inch in diameter, the centres of which were caseous. These tubercles were evenly distributed in both lungs and roughly averaged from one to one and one-half inches apart. They could be plainly seen and felt through the transparent pleura. The apex of the right lung contained a caseous area two inches in diameter, which was made up of many adjacent small tubercles. The bronchial and mediastinal lymphatic glands were enlarged and contained cheesy areas from one-sixteenth to one-third of an inch in diameter. The post-pharyngeal lymphatic glands were enlarged to the size of an egg, hyperæmic, and on section showed numerous caseous areas.

The second vaccinated animal (45066) was killed October 16th. At the two points of insection of the needle when the animal was inoculated, July 29th, there were two somewhat hard, globular fibrous thickenings one-quarter to three-fifths of an inch in diameter, respectively. Within the trachea, and occupying positions corresponding to these, were two very small (pin-head) grayish elevations in the mucous membrane. Upon section it was found that the upper of these small thickenings was made up of fibrous tissue, the lower (the smaller one) contained a focus of caseous material surrounded by thick, fibrous walls. The whole appearance was that of a closed process. No other lesions were found in any part of the body. All of the organs, their lymphatic glands and covering membranes, appeared to be quite normal. There was no thickening of the wall of the jugular vein at the point of vaccination.

The second control (unvaccinated) heifer (45067) was killed October 16th. The post-mortem report is as follows: Beneath the skin in the middle of the neck, at the point of inoculation, there was an abscess about two inches in diameter that contained cheesy pus. All

of the inferior cervical and suprasternal lymphatic glands were enlarged to several times their normal volume and contained numerous areas of caseation. Within the trachea, from the point of inoculation down to its bifucation and up to the glottis, the mucous membrane lining the ventral half of the tube was thickly studded with oblong red, and evidently young and progressive tubercular growths. These formations were from one-sixth to one-half an inch long, and about two-thirds as wide; they stood above the surrounding surface from one-twelfth to one-half an inch. The post-pharyngeal lymphatic glands were enlarged to the size of a hen's egg and loaded with caseous material. The lungs contained many grayish nodules one-eighth to one-quarter of an inch in diameter. The smaller were grayish throughout, while the larger had yellow, cheesy centres. These nodules were not set so thickly as in the other control heifer (45071). They averaged from four to five inches a part, and were very evenly distributed throughout both lungs. The mediastinal and bronchial lymphatic glands were enlarged to twice their normal size and contained much caseous material. Many (about eighteen) of the lymphatic glands of the mesentery were enlarged and caseous. No alteration could be found in the mucous membrane or the walls of the intestine. The infection of the mucous membrane of the trachea above the point of inoculation appears to have been due to the carriage upward by coughing of some of the tubercle bacilli at the time of inoculation. It is well known that cattle habitually swallow their expectorations, and this may account for the infection of the post-pharyngeal and mesenteric lymphatic glands.

From the experiments here recorded we believe that we are justified in concluding:

1. That after repeated intravenous injections of cultures of tubercle bacilli from human sputum the resistance of young cattle to virulent tubercle bacilli of bovine origin may be increased to such an extent that they are not injured by inoculation with quantities of such cultures that are capable of causing death or extensive infection of cattle not similarly protected.

2. That by intravenous injection much larger quantities of culture of human sputum tubercle bacilli than are necessary to confer a high degree of resistance, or immunity, upon the vaccinated animal may be administered without danger to that animal.

We now have in progress incomplete experiments upon a number of young cattle, some of which have been underway since last March, for the purpose of testing the duration of this immunity and the extent to which it is effective in protecting cattle against infection from natural sources. We have also started an experiment which we hope will throw light upon the open question as to the minimum quantities of culture of non-virulent tubercle bacilli that it may be

necessary to administer in order to confer a serviceable degree of immunity, and, further, whether it may be possible to simplify the process of vaccination by successive injections of a few cultures of propressive degrees of virulence.

In conclusion, we wish to express our thanks to Dr. M. P. Ravenel and to Dr. H. C. Campbell; to the former for the originals of most of the culture used, and to both for general assistance during the progress of the experiments. We also wish to thank the authorities of the Veterinary Hospital and of the Pepper Clinical Laboratory of the University of Pennsylvania, who have generously furnished the State Live Stock Sanitary Board with a laboratory and with other facilities, without which its research work would have been impossible.

Anthrax.—Anthrax has occurred in the following counties: Bradford, Chester, Clarion, Cumberland, Erie, Franklin, Jefferson, Lancaster, Lycoming, McKean, Perry, Sullivan, Susquehanna, Wayne, Warren and Wyoming. There have been from one to twenty deaths from each outbreak. The use of anthrax vaccine has continued to afford valuable protection to animals necessarily exposed to the disease. There are still localities and farms in the State where it is impossible to raise cattle without the protection of vaccination against anthrax. Such vaccination not only protects the animals that are vaccinated but, by keeping them from contracting the disease, the infection of the soil is prevented and thus new centers of infection are kept from occurring. The number of animals that it has been necessary to vaccinate is 688. In view of the public importance of preventing outbreaks of this most dangerous disease it has been considered justifiable to carry out such vaccination at the expense of the State, and this has been done in every case. No animal has died of anthrax during the past year after it has received the double vaccination.

The act passed by the last Legislature to provide for the prevention of the spread of disease from the carcasses of animals that die of dangerous or virulent disease, has proved to be of great value. This act makes it necessary for the owners of such animals to care for their carcasses. If the carcass is neglected and is permitted to lie on top of the ground the germs of the disease that are spread from it by currents of water, by insects, by large animals or even by the air, may serve to infect a large area. The act referred to provides a penalty for neglect of such carcasses after the owner is notified as to their existence; and it provides further, that where such neglect occurs the carcass shall be disposed of by the State Live Stock Sanitary Board or the local board of health, or, in the event that there is no local board of health having jurisdic-

tion, then by the township auditor of the township in which the carcass may be. The cost of disposing of the carcass in this way is to be paid by the State Live Stock Sanitary Board, and is to constitute a lien on the property of the owner of the animal at the time of its death, and it is the duty of the State Live Stock Sanitary Board to attempt to recover by due process of law from the owner the amount expended by it in disposing of or destroying the carcass.

So far as is known, no additional outbreaks of anthrax have occurred in this State as a result of infection from outside of our borders. The owners of cattle in the localities where the disease is most prevalent are now informed as to the urgent necessity of cremating the carcasses of all animals that die of this disease and of vaccinating cattle on exposed lands. These are the most important points to observe in connection with the control of an outbreak of anthrax and by means of them the disease is kept well in hand in this State.

The thing that it is first necessary to determine where anthrax is suspected is whether the disease is anthrax or not. It is safest not to attempt to settle this question by making a postmortem examination on the carcass of the suspected animal. Where such a postmortem examination is made the operator exposes himself to grave danger. Many lives have been lost from anthrax as a result of wounds infected from carcasses of dead animals. Moreover, if the carcass is opened the blood flows upon and into the surrounding soil. This blood, if the animal died of anthrax, is loaded with germs and spores of this disease. Spores of the anthrax bacillus are exceedingly resistant organisms and will live in the soil exposed to all the changes and extremes of temperature and moisture for a period of several years; possibly as long as ten years. When soil is infected in this way there is constant danger to animals that graze over it or that feed upon the products from it, or that drink water that has flowed over it or through it.

If the diagnosis cannot be made from the symptoms alone, it is best to treat the carcass as though it was known that the animal had died of anthrax, and thus be on the safe side, but in order that the facts in the case may be revealed and uncertainty avoided in future cases of a similar nature, a sample should be sent to the laboratory of the State Live Stock Sanitary Board, 36th and Spruce Sts., Philadelphia, for examination. This sample should consist of an ear of the dead animal cut off close to the head. Such a specimen will contain enough blood to enable a bacteriologist to make a diagnosis of anthrax or to exclude this disease. The ear should be wrapped in waxed parchment paper using several thicknesses and covering the package several times with separate sheets, so that leakage may be impossible. Or, the ear may be placed in a glass fruit jar which may be sealed. The package

or jar should then be placed in a large bucket, such as a tobacco or candy bucket and surrounded with ice. It is then ready to be expressed to the laboratory. A tag should be affixed stating the name of the sender and a letter should be written giving all the known facts as to the history and nature of the disease.

It has been shown by some recent experiments made by Lothes and Profé of Cologne, that anthrax spores pass with the help of water through strata six feet thick of very compact sand and gravel in about thirty hours. This established fact goes to show how dangerous it is to bury the carcass of an animal that has died of anthrax, and supports the opinion that it is always best to dispose of such carcasses by burning. Instructions have been given in a previous report for burning anthrax carcasses. An effective method is to use railroad ties or large sticks of timber from six to ten feet long. A layer of these is to be laid on the ground, the sticks being parallel; a second layer is then to be laid, the sticks being at right angles to those of the lower layer. The wood should then be well wet with coal oil and the carcass drawn to the top of the pile by sliding it along on skids. Skids can be made of round poles five inches in diameter and ten or twelve feet long. A pile of from eight to twelve railroad ties will suffice to cremate the carcass of an animal weighing 1,000 pounds.

Some experiments made by Dr. Profé in cremating the carcasses of animals are very instructive and his results are stated below. His article on this subject is published in the Berlin Veterinary Weekly, and is abstracted in the Veterinary Journal, Vol. VII, No. 37, in part as follows:

"It has been thought impossible to destroy carcasses at an open fire, but Dr. Profé says that in 1900-1901 in the province of Posen he destroyed, with the approval of the owners, several anthrax infected carcasses in this way. The burning was effected in a comparatively short time and with wonderfully little expenditure of fuel if the carcass was placed on iron rails placed over the pit. He relates a case in point: A well nourished cow had fallen a victim to the disease and the carcass was brought out into a pasture field, where a postmortem was held by the veterinary surgeon of the place. As the transport of the carcass to the ordinary burial place of the district was not possible with the means at hand, and as there seemed to be no other means of disposing of the carcass, it was resolved to try burning. For fuel; peat briquettes were used, with petroleum to set them on fire. When the thing was fairly ablaze the farmer stopped the supply of fuel, but thanks to the amount of fat on the animal the burning was completed, but it took nearly forty hours to effect the destruction of the animal, which weighed some 1,100 pounds. The cost was about 75 cents. Drs. Lothes and Profé resolved to try burning over an open fire at

the municipal burying place at Cologne. On the 15th of July the skinned carcass of a horse was, with its entrals, weighing in all about 1,200 pounds burnt over an open fire. This fire was lighted in a pit about three feet deep, and over it the carcass was placed on two iron rails about six feet long, lying diagonally. For fuel there was used 200 pounds wood, 300 pounds of briquettes and 50 pounds of coal tar. At the beginning 50 pounds of wood and 50 pounds of briquetts were set on fire under the carcass, which was soaked in tar, and the rest of the fuel was used as required. The fire was lighted at 6 P. M. and on the following day at 2 P. M. there was only a small heap of smoking ashes. Smoke lasted only until the tar was consumed. The cost was $1.75. Another case lasted twenty-six hours and cost about $2.00. A third case, this time an ox, lasted only eight and a quarter hours and cost $1.75. It was found that tar keeps up the flame better than resin and much better than petroleum. In these three cases the influence of the wind was found to be unfavorable whether it blew along or across the pit. It was therefore found to be desirable to make the pits deeper and lay the carcasses further down and this was arranged in the following way: A pit was made about six feet long, six feet bread and two and one-half feet deep, and then a further excavation was made of the same length and breadth but only 36 inches broad, so that part of the "floor" of the upper excavation formed the borders of the lower 18 inches on each side. On these borders the iron rails were placed diagonally, and on the rails the disembowelled carcass was laid, belly downwards. The fuel had, of course, been previously laid on the floor of the lower pit. The viscera was placed on the borders of the lower pit, whence, as the process of cremation went on, they fell gradually into the glowing mass. A few cases may be cited in illustration of the process: A horse weighing about 1,600 pounds was cremated with 650 pounds of wood; the operation took about ten hours and cost about $2.00. Another horse, weighing about 850 pounds, was cremated with 450 pounds of wood and 30 pounds of tar; the operation took five and one-half hours and cost $1.75. An ox weighing 600 pounds was cremated with 300 pounds of wood and 30 pounds of tar; the operation lasted three and one-half hours and cost $1.25. It is noted by the writers that town prices were charged for the wood, in the country it would be very much cheaper. They distinctly recommend the second method (the double pit) as requiring less fuel and occupying less time; besides, it is independent of the wind, and as the pits have often to be dug the day before the operation this is no small matter. They further recommend coal tar as preferable to petroleum, and advise that the carcass be smeared with it before burning. The place of cremation need not be very carefully chosen. Smoke is

developed only at the beginning of the operation, and therefore little annoyance may be feared from this cause. The same may be said about the gases evolved in the process; no smell was perceptible more than one hundred yards away, and this only in the direction of the wind. Of course the cremation ought to take place on the spot where the post-mortem is held, and that must be at least one hundred yards away from human habitation."

Black Quarter.—Black quarter has been found to exist in the following counties: Erie, Forest, Franklin, Jefferson, Lackawanna, Monroe, Pike, Perry, Potter, Susquehanna, Wayne and Warren. The principle of controlling this disease is similar to that observed in controlling anthrax. It is necessary to prevent the contamination of the soil by burning the carcasses of the victims of this disease. Vaccination against it is effective and has been applied during the year to 765 animals. On some farms the rearing of young cattle without vaccination is impossible. The vaccine used for this work has been obtained from Dr. D. E. Salmon, Chief of the Bureau of Animal Industry, Washington, D. C., and has been effective in every instance.

Haemorrhagic Septicaemia or Spotted Fever of Cattle.—This is the disease that has been known heretofore in Pennsylvania as "Carbon County Disease" or "Mountain Disease of Cattle;" it is known in Germany as "Rinderseuche" and in southern Europe as "Barbone." It has existed in Pennsylvania for many years, but has not been positively identified until the past summer. In an investigation of an outbreak in Carbon county, in the vicinity of Tamauqua, made by Dr. Gilliland and myself, it was possible to obtain complete proof as to the identity of this disease and there can be no doubt that the various outbreaks of a similar nature that hav oc-curred in the rougher and mountainous parts of the State are also occurrences of the same malady. This disease is believed to have occurred during the past year in the following counties: Cameron, Carbon, Centre, Clearfield, Franklin, Forest, Huntingdon, Lackawanna, Lycoming, Perry, Potter, Somerset, Wayne and Warren. The chief symptoms are: Fever, loss of appetite, dullness, diminution of milk flow, groaning, discharge of bloody mucous from the nose, staring coat, red mucous membranes, swelling about the throat; which is hot, rather tense and painful and is sometimes accompanied by harsh or difficult breathing. There is usually a little discharge of blood from the anus. Sometimes there is a little leakage of blood through the skin at various points as though the animal had been stung by large flies or pricked with needles. In other cases the disease seems to affect the intestinal tract chiefly and in this case there is a diffuse haemorrhagic gastro-enteritis, causing much depression, accumulation of gas, evidence of pain in the abdominal cavity and the faeces are

covered with blood, shreds of firbin or mucous. The course of the disease is usually short, varying from twelve hours to a week, and it terminates in death in nearly all cases. On post-mortem examination it is observed that the tissues beneath the skin in the region of the throat are infiltrated with serum and that scattered through this infiltrated area there are many points of haemorrhage; sometimes the haemorrhage is extensive causing the entire infiltrated area to be of a red color. This swelling about the throat usually involves the walls of the pharynx and larynx. The root of the tongue is often swollen and infiltrated with yellow serum. Points of haemorrhage may be observed beneath the skin on any part of the body. Sometimes the lungs show evidence of haemorrhage into them and there is an accumulation of blood in the chest cavity. If the intestines are involved there is haemorrhage into large or small areas of the wall causing it to be of dark red color and considerably thickened. The appearance of the blood is not materially altered; it coagulates in the usual way. The most characteristic alterations are the points of haemorrhage indicating an escape of blood from the vessels into the subcutaneous connective tissues and into the lining membranes of the adbominal and thoracic cavities and into the swollen areas about the throat and at the root of the tongue. Young or old cattle may be afflicted by this disease.

The cause of haemorrhagic septicaemia is a bacillus that was discovered by Kitt in 1885. This organism has since been studied by numerous bacteriologists in various parts of the world and has been identified as the cause of this disease in Italy, France, Algiers and Denmark as well as in Germany. In 1891, it was shown by Brimhall and Wilson to be the cause of a disease occuring among the cattle of Minnesota that they proved to be identical with the German "Rinderseuche." It is somewhat difficult to obtain primary cultures of this germ from the blood or tissues of an afflicted animal; special culture methods have to be employed.

This disease may readily be mistaken for anthrax, black quarter or some kind of forage poisoning. In anthrax the bacteriological examination readily established the diagnosis and removes all doubt. In black quarter the swelling is not likely to be confined to the region of the throat and head as in this disease, but is likely to involve the side of the body or one of the legs. Moreover, the swelling is not tense and hard as in haemorrhagic septicamia or spotted fever, but is soft, elastic and crackles upon pressure. When cut into, the swelling of black-leg is found to contain a very dark, frothy fluid. Forage poisoning can be recognized only by taking into careful consideration the history of each case and the local conditions. Perhaps the most common form of forage poisoning of

cattle is the so-called "corn stalk disease." This has been recognized a number of times in Pennsylvania. This disease occurs among cattle fed on corn fodder that has been poorly cured and is more or less damaged by mould. Other damaged foods may produce condition very similar to "corn stalk disease."

Haemorrhagic septicaemia or spotted fever of cattle can be prevented from spreading by restricting the movement of animals afflicted with the disease. Such animals should be kept near the place where they are found when the disease is recognized, and if they die their carcasses should be cremated in the same manner as the carcasses of animals dying of anthrax. The internal treatment of afflicted animals has not been successful enough to afford much encouragement. The most successful method that has been tried, so far as I know, consists in the intravenous administration of a solution of colloidal silver. The premises occupied by the diseased animals must be very thoroughly disinfected. Lands that are known to be infected should not be used for cattle for a few years.

Numerous experiments have been made with the view of obtaining a vaccine against this disease, and these have met with a certain amount of success. Vaccination of cattle against haemorrhagic septicaemia is said to be practiced extensively in parts of Russia and it has been tried in Italy. This system of protection has not been experimented with in the United States, and so there is no information as to its value under the conditions existing here. Attempts will be made to determine the precise distribution of this disease and to place in the hands of persons concerned so much information as is available in regard to the means to be employed to prevent it.

Abortion.—Abortion of cattle has been reported from various sections of the State and appears to be in some places a common scourge of breeding herds. Fortunately, it is less common than was formerly the case, and this is due, no doubt, to the fact that it can now be prevented or eradicated from an infected herd by the use of appropriate precautions or treatment. The means that are proven to be successful as a result of numerous trials and experiments are summarized below:

DIRECTIONS FOR THE TREATMENT OF AN ABORTING HERD.

1. Burn aborted foetuses and membranes.

   This material carries the germs of abortion in abundance and burning or deep burial furnish the only means of getting rid of it in a safe way.

2. Isolate discharging cows.

   The vaginal discharge from cows that have aborted is very virulent and may furnish the means of infecting other cows. Hence, discharging cows should be kept apart from the herd.

3. Disinfect the premises.

This procedure should be executed with the most exacting care. Partial or inefficient disinfection is practically useless. To disinfect, where fumigation with the vapor of formaldehyde cannot be employed, the spray pump furnishes the best means. It should be borne in mind that disinfectants do not destroy germs that they do not come in contact with. So, all large accumulations of bedding, forage and manure should be removed and every place that may harbor a germ should be reached with the disinfectant. Especial care should be used to drive it into every crack, knothole, behind every loose board, on top of every beam and into every partly concealed hole as well as upon every exposed surface.

A five per cent. solution of good (not crude) carbolic acid may be used for this purpose.

Following the disinfection by spraying and the cleaning of the stable, it may be whitewashed with lime wash containing one pound of fresh chloride of lime to each three gallons of water. This may be applied with a brush or, better, with a spray pump.

The barn yard should be well cleaned out, the manure being spread in some field that cattle do not have access to. The bottom of the yard should be well scraped and the earth stained with leachings from manure should be removed. Then, the surface of the yard may be flushed with a saturated solution of sulphate of iron or thickly spread with lime. The outer well of the barn, facing on the yard, and the adjoining fences should be disinfected or whitewashed.

4. Irrigate the genital passages of the cows that have aborted.

The purpose of this procedure is to disinfect the genital passages. A convenient method is as follows: Hang a bucket containing the antiseptic solution back of the cow. To a spigot on the side of this bucket attached a rubber hose five-eighths inch in diameter and about six feet long. Insert the hose into the vagina and, if possible into the uterus of the cow. Allow from three to four quarts of the warm solution to flow into the cow and out. Take a fresh hose and irrigate the next cow, allowing the hose first used to soak in an antiseptic solution in the mean time.

This treatment should be repeated every second or third day so long as there is any discharge from the cow. Afterwards it may be used once or twice a week. As appropriate solutions, the following are recommended: Lysol, one per cent.; creolin, two per cent.; bichloride of mercury, 1-3000; carbolic acid, one and one-half per cent.; boracic acid, three per cent.; permanganate of potash, one per cent.; alum, one per cent; chloride of zinc, two per cent. The last injection, two days before service, should be bicarbonate of soda, two per cent.

5. Irrigate the sheath of the bull.

The purpose of flushing out and disinfecting the sheath and the outside of the penis of the bull, is to prevent him from carrying the germs of abortion from one cow to another. This procedure should be enforced before and after each service. This is very important. The sheath may be flushed out by using a small rubber hose and funnel. The end of this hose is to be inserted into the sheath beside the penis, the fore-skin is held together with the fingers and the antiseptic is poured into the funnel. A one per cent. solution of lysol is good for this purpose.

6. The long hair at the end of the bull's sheath should be cut off.

   Moreover, it is well to clip the hair from under the belly over a circle one foot in diameter surrounding the opening of the sheath. Then, by washing with a sponge this area can easily be cleaned before each service.

7. Wash off the external genitals of each cow every day.

   For this purpose use any of the antiseptic recommended above. They can be applied with a clean sponge. The parts washed should comprise the root of the tail, the anus, the vulva, and the surrounding skin for a distance of several inches, and the corresponding portion of the tail. A separate bucket and sponge should be used for the cows that are pregnant and those that have recently aborted.

8. Do not breed a cow for ten weeks after she has aborted.

   About ten weeks are required for the thorough treatment of a cow that has aborted and she should not be bred before the expiration of this period. If she shows any discharge or other indication of vaginal catarrh she should not be bred for a longer period, or until the parts are in an entire normal condition.

9. A solution of carbolic acid may be administered subcutaneously to each pregnant cow.

   For this purpose use a three per cent. solution of carbolic acid and of this, inject two drachms every ten days. Should this cause swelling in some individuals, for these use a smaller amount.

10. Remove cows from the herd before they abort, if possible.

    The purpose of this is to prevent the re-infection of the premises. Of course, this cannot always be done and when a cow aborts in the cow stable thorough disinfection is again required.

11. Repeat the disinfection of the stable from time to time and pay particular attention to cleansing and disinfecting the gutters.

    For frequent flushing of the gutters use a saturated solution of sulphate of iron.

12. Treat the cows according to their individual needs.

    If a laxative or tonic is needed, give Sal. car, fact or iron or arsenic according to the indications.

13. Whenever possible, it is well to use a separate bull for the cows that have aborted and another for the sound cows.

    But even in this case it is important to observe the precautions cited under heading No. 5, using a separate apparatus for each bull.

Ergotism.—There was one outbreak of ergotism during the year and it was investigated and reported upon very fully by Dr. Jacob Helmer, of Scranton. The disease investigated by Dr. Helmer occurred on a farm in Wayne county. In this herd there were 12 cattle, 10 cows and 2 yearlings, and of these 9 were afflicted with ergotism. Three of the cows had died before the investigation was made on the 10th of April, 1902. In these animals, there was gangrene of the extremities, the ear tips became dry, brittle and finally dropped off, the process gradually extending toward the base of the ear. Some of the animals had lost their tails in the same way, others had lost their feet and in one animal two legs had separated at about the middle of the cannon bone. The trouble had been in progress from the previous January. It was found to have been due to ergot growing on red top hay. Some samples of this red top hay was sent

to the University of Pennsylvania and was examined by Prof. John W. Harshberger, who reported that the numerous black specks, resembling black seeds, growing among the seeds of the grass, were the spurs of ergot.

Forage Poisoning.—Forage poisoning of horses has not prevailed during the past year to the very serious extent that has characterized its prevalence in some previous years. The chief difficulty with this disease has been in the following counties: Berks, Bucks, Chester, Adams, Allegheny, Franklin, Lehigh, Montgomery and Philadelphia. This disease has been proven to be due to damaged food or contaminated water. The precise source or nature of the contamination has not been discovered, but it has been possible in an experiment to reproduce the disease by feeding to horses mouldy silage. In an outbreak in a large stable in Philadelphia, during which about thirty-five horses died, a careful pathological study of specimens from some of these horses was made by Dr. D. J. McCarthy and will be reported upon later by him. The bacteriological examinations that were made during this outbreak, as those made previously, have resulted negatively. So much is known, however, that there is ample reason for recommending that no damaged food should be fed to horses. Hay, fodder, straw, silage, grain or mill feed that is mouldy, heated or sour cannot be fed to horses safely. Contaminated wells may furnish water poisonous to horses and instances have been found wherein it has been possible to definitely trace this disease to a well receiving drainage from a stable or leakage from a barn yard.

Glanders.—Glanders has occurred in the following counties: Allegheny, Bucks, Bradford, Centre, Chester, Clearfield, Cumberland, Dauphin, Franklin, Lancaster, Luzerne, McKean, Philadelphia and Wyoming. Seventeen, or practically one-half of the thirty-five cases that occurred during the year, were among mules of one mining company in Luzerne county. These mules are believed to have been infected through the purchase of some infected mules in the stock yards at East St. Louis. The infection reached the mules that were in four mines, and in order to check the outbreak it was necessary to keep a careful oversight for a period of about six months and to test many animals with mallein. Because the outbreak was reported so soon after it started there was not the opportunity for the distribution of the disease that would otherwise have occurred. On this account it was not necessary to test with mallein all of the mules in the various mines belonging to this comapny. The plan that was adopted consisted in making a very careful physical examination of all the mules and in removing from the mines to test with mallein every animal that showed symptoms in the least degree

suspicious. After these animals had been kept out of the mine under observation for a few days and were tested, they were returned to the mines if they did not react to the mallein test and if further study of the conditions causing suspicions failed to support the thought that these symptoms might have been produced by infection with glanders. In this way, the work of the mines was not seriously interfered with. It is believed that the outbreak has been completely suppressed and for the reason that during the past five months no evidence of glanders has been discovered among any of the mules belonging to this company.

In an outbreak in Franklin county several horses and mules belonging to a farmer were infected by a mustang from the west. In treating these animals, before it was known that they were suffering with glanders, and before the matter was reported to the State Live Stock Sanitary Board, the owner contracted the disease himself and died of it.

Almost every case of glanders that has occurred in the State during the past year has been traced directly to infection from without. So far as known, all of the infection that exists in the State has been located and eradicated. If so, there will be no more cases in Pennsylvania until it is re-introduced. However, it is not difficult for this to occur. There is no inspection of horses coming into the State, and glanders is a very prevalent disease in most of the States bordering upon Pennsylvania. So it is necessary at all times to maintain a careful watch to discover outbreaks before they have made headway and to check them while but a few animals are involved. The dangers attending this disease are so well understood and the veterinarians in Pennsylvania are so skilled in diagnosing it that, as a rule, there is little delay in obtaining reports upon it.

Texas Fever.—There has been no Texas fever in Pennsylvania for a long series of years, until last winter. The immunity from Texas fever that we have experienced is due entirely to the wise regulations that have been drafted and are enforced by the Bureau of Animal Industry of the United States Department of Agriculture. Since Texas fever has not occurred in Pennsylvania for so long, little attention has been paid to facts regarding it by the breeders in this State. Therefore, it may not be out of place to say that Texas fever is a specific disease somewhat resembling malarial fever of man, and is caused by small animal parasites that live in the blood and destroy the red corpuscles. Nearly all of the native cattle of the southern States have this disease continually, but in a form so mild that it does not appear to injure them. The parasite of the disease is carried by the cattle tick. The progeny of ticks that have fed upon blood of cattle infected with the parasites of Texas fever are capable of transmitting these parasites to the animals that they

infest. The disease is not propagated by direct contact between diseased and healthy cattle but only through the agency of the tick, as stated.

The Bureau of Animal Industry of the United States Department of Agriculture has established a line extending from the eastern to the western coast of the Continent, below which the country is known to be permanently infested with the southern cattle fever tick and above which infestation is not known to exist. This line, which is changed from time to time, is known as the southern cattle fever quarantine line. It is provided that shipments of cattle from points south to points north of this line shall take place only in placarded cars; the placards announcing that the cattle are southern cattle and that the cars are to be disinfected when unloaded. The cattle thus shipped must be for immediate slaughter and they are unloaded directly at the slaughter houses and carried through special chutes to yards reserved exclusively for animals of this description. It is only during a period of a few weeks in mid-winter that it is permitted to bring southern cattle north without restriction. During cold weather the ticks are dormant and they cannot multiply, so that free shipments may occur during the cold weather. The open shipping season is defined each year by proclamation of the Secretary of Agriculture. When northern cattle are carried south of the quarantine line they are then regarded as and are subject to the same rules as southern cattle.

Last winter, during the Charleston Exposition, a special exception was made to the quarantine regulation, under which northern cattle were allowed to be sent south to the Exposition and then returned to the farms of their owners in the northern States. Three herds were exhibited from Pennsylvania. A few cattle in two of these herds became infested by the southern cattle fever tick, presumably while in the yards of the Charleston Exposition. They were thus inoculated with the organism of Texas fever, developed the disease and perished by it while on the way home or after arrival in this State. Fortunately, the trouble occurred during cold weather so that there was no danger that the disease might be transmitted to other cattle, and such transmission, as a matter of fact, did not occur. The loss that fell upon Pennsylvania exhibitors was serious but not so serious as that which fell on some exhibitors from other States.

This occurrence is very instructive in that it shows the value of the protection against Texas fever that is afforded the cattle interests of the United States by the well planned and effectively administered regulations of the Bureau of Animal Industry of the United States Department of Agriculture. Were it not for these regulations Texas fever would occur every summer in Pennsylvania, following the im-

portation of southern cattle. Not many years ago, Texas fever was an annual visitor and always caused losses amounting to many thousand dollars.

Rabies.—Outbreaks of rabies have occurred in the following counties: Allegheny, Armstrong, Beaver, Bedford, Berks, Bucks Carbon, Centre, Chester, Clarion, Clinton, Crawford, Erie, Greene, Indiana, Lackawanna, Lancaster, Lawrence, Lehigh, Luzerne, Lycoming, Mercer, Montgomery, Montour, Philadelphia, Schuylkill, Tioga, Venango, Warren, Wayne, Washington and Westmoreland. Before this disease can be effectively checked it is necessary that there shall be more authority to quarantine dogs in infested districts. It is important that the authority shall be conferred upon the State Live Stock Sanitary Board to destroy dogs running at large in violation of a quarantine established to prevent the spread of this disease. A bill to grant this authority will be presented to the next Legislature, the text of which follows:

An act to prevent the spread of the disease known as rabies or hydrophobia, and to authorize the quarantine, restraint, confinement or muzzling of dogs during outbreaks of this disease and to empower the State Live Stock Sanitary Board to enforce the provisions of this act.

Section 1. Be it enacted, etc., That whenever the disease known as rabies or hydrophobia shall occur among the dogs or other animals in any locality in Pennsylvania and it is adjudged by the State Live Stock Sanitary Board that the disease is spreading or is liable to be spread by dogs that have been exposed, the said board may order the quarantine, restraint, confinement or muzzling of any or all dogs within the limits of the locality in which the danger of infection is deemed to exist. The authority hereby conferred is not to annul or restrict the authority now possessed by cities or boroughs to quarantine, restrain, confine or muzzle dogs within the limits of their respective jurisdictions.

Section 2. A quarantine or order to restrain, confine or muzzle dogs shall be operative when it is approved by a majority of the members of the State Live Stock Sanitary Board and when a copy of it has been left at the usual place of residence of the owner of the dog that is believed to have been exposed to rabies or hydrophobia or when the notice or order to quarantine, restrain, confine, or muzzle dogs has been published in each of two papers in each of the counties within which the regulation is established and when printed notices giving the text of the regulation or order have been posted in public places in the locality in which the regulation or order applies.

Section 3. Should dogs be permitted to run at large or to escape from restraint or confinement or to go without muzzles in violation of the quarantine or regulation or order established by the State Live Stock Sanitary Board to restrict the spread of rabbies or hydrophobia as provided by this act, such dogs may be secured and confined or they may be shot or otherwise destroyed and the owner or owners thereof shall have no claim against the person so doing.

Section 4 Any person violating the provisions of this act or of a quarantine or of a regulation or order to restrain, confine or muzzle dogs duly established by the State Live Stock Sanitary Board for the purpose of restricting the spread of rabbies or hydrophobia in the manner provided in the other sections of this act, shall be deemed guilty of a misdemeanor and upon conviction shall forfeit and pay a fine of not less than ten dollars nor more than one hundred dollars, at the discretion of the court.

More rational views in regard to this disease are beginning to prevail. One hears less of absurd opinions as to the non-existence of rabies. It is most interesting and astonishing that this impression could have prevailed in so many quarters for so long a time. There is no disease that is more definite in its manifestations than rabies, and it would be quite as rational to claim, and as easy to support the view, that there is no such disease as anthrax, glanders or tuberculosis as that rabies is a mythical disease.

The rapid diagnosis of rabies that is made in the laboratory of the State Live Stock Sanitary Board by Dr. M. P. Ravenel, is an item in the repression of rabies that is of great importance and is constantly becoming more important, as it is more used. For example, a rabid dog, or a dog supposed to be rapid may bite a large number of dogs in a town and then die or be killed. If it is not known positively that this dog was afflicted with rabies but little would be done by the local authorities in the way of controlling the movements of the dogs that were bitten. If, however, the head of the dog in question is sent to the laboratory and the diagnosis of rabies is positively established, the local authorities are usually not slow to move in the matter of controlling or ordering the destruction of exposed dogs. On the otherhand, if it is found the disease is not rabies then, of course, all alarm is at once removed.

The number of deaths from rabies during the year has been quite large. More horses, cattle, sheep and dogs have died of rabies during the year 1902 than during any other recent year; the exact numbers are not available because a report is not required and only a fraction of the cases that actually occur are reported. Probably as many as four hundred horses, cattle, sheep, swine and dogs have died of rabies during the year, or have been killed while afflicted with this disease.

The law enacted by the last legislature, providing for payment from the dog tax fund for animals that die of or have to be killed on account of rabies is gradually becoming known throughout the State, and many claims are being made upon the counties for compensation under this law. The effect of this is to bring to the attention of the local authorities the importance of repressing this disease, and this will no doubt, in time, have the beneficial effect of building up public sentiment in favor of measures directed against rabies.

A great deal of good could be done by reducing the size of the canine population of the State. There are altogether too many homeless and worthless dogs in Pennsylvania. These wandering, suffering animals are not only frequently exposed to rabies and do a great deal to carry it from place to place but they work harm in another way, by damaging the sheep industry. There were in Pennsylvania in 1901, 1,602,107 sheep; in 1900, there were 957,483 sheep, a loss of 40.5 per cent. This loss appears to continue and in the face of the highest prices for wool and mutton that have prevailed for many years. There can be no doubt that a large amount of this decrease in sheep is due to the difficulties sheep owners experience from dogs. There are parts of Pennsylvania that are admirably adapted to sheep growing and that are not well adapted to other kinds of agriculture, but the sheep grower can hardly afford to risk the injuries to his flocks that are constantly occurring as a result of these visitations of sheep killing and sheep chasing dogs.

Hog Cholera.—Losses from hog cholera during the year are estimated at about $110,000. These losses have been traced in most cases to the introduction of hogs from outside of the State. It may be that these hogs were healthy when they were shipped, but after passing through stock yards and stock cars they developed cholera and propagated the disease. It is a matter of common knowledge that it is almost fatal to swine to pass them through any one of the larger stock yards, and it is very risky to ship hogs in stock cars unless they have been recently cleaned and disinfected. The reason for this is that a very large number of hogs suffering from cholera, or that have recently partly recovered from the disease are sent to market, and so the channels through which they pass become infected. It would be very useful to shippers if some arrangement could be made whereby stock yards and stock cars should be frequently cleaned and disinfected.

During an outbreak of cholera it is important that the infected swine shall be quarantined in order to prevent their carrying the disease further; that the carcasses of hogs that die of cholera shall be cremated; that the pens occupied by the infected animals shall be disinfected at short intervals, and that the animals still sound shall

be placed in separate pens and treated by medicine made according to the formula below, which is recommended by the Bureau of Animal Industry. The following is taken from one of their reports:

	Pounds.
"Wood charcoal,	1
Sulphur,	1
Sodium chloride,	2
Sodium bicarbonate,	2
Sodium hyposulphate,	2
Sodium sulphate,	1
Antimony sulphide (black antimony),	1

"These ingredients should be completly pulverized and thoroughly mixed. In case there is profuse diarrhea the sulphate of sodium may be omitted.

"The dose of this mixture is a large tablespoonful for each 200 pounds weight of hogs to be treated, and it should be given only once a day. When hogs are affected with these diseases they should not be fed on corn alone, but they should have at least once a day soft feed, made by mixing bran and middlings, or middlings and corn meal, or ground oats and corn, or crushed wheat with hot water, and then stirring into this the proper quantity of the medicine. Hogs are fond of this mixture, it increases their appetite, and when they once taste of food with which it has been mixed they will eat it though nothing else would tempt them.

"Animals that are very sick and that will not come to the feed should be drenched with the medicine shaken up with water. Great care should be exercised in drenching hogs or they will be suffocated. Do not turn the hog on its back to drench it, but pull the cheek away from the teeth so as to form a pouch, into which the medicine may be slowly poured. It will flow from the cheek into the mouth, and when the hog finds out what it is, it will stop squealing and swallow. In our experiments hogs which were so sick that they would eat nothing have commenced to eat very soon after getting a dose of the remedy, and have steadily improved until they appeared perfectly well.

"This medicine may also be used as a preventative of this disease, and for this purpose should be put in the fed of the whole herd. Care, of course, should be observed to see that each animal receives it proper share. In cases where it has been given a fair trial, it has apparently cured most of the animals which were sick and has stopped the progress of the disease in the herds. It also appears to be an excellent appetizer and stimulant of the processes of digestion and assimilation, and when given to unthrifty hogs it increases the appetite, causes them to take on flesh, and assume a thrifty appearance."

Foot and Mouth Disease.—In November, the country was startled by the knowledge that foot and mouth disease existed in some of the New England States. While the outbreak did not cover a large extent of territory or involve more than three thousand cattle it was still a very serious matter, because of the possibilities for harm that are attached to this disease. The source of the present outbreak in the New England States is unknown; it is merely known that the disease has existed there in a restricted locality near Boston, for a period of several months. The reason that it has not spread more rapidly is, that it happens to have been in a region where all the trade in cattle centres toward a single point, viz: Boston. If there were much of an outward trade in cattle from the Boston markets the disease would have been distributed at a very much more rapid rate, and in the time during which it has existed it might have reached distant parts of the country. It is true that there is some out-bound trade in cattle through Boston, but this is chiefly in cattle for export. Export cattle shipped from Boston, come from Canada and from the western states, they remain in Boston but a short time before they are loaded on the ships. During the time that they are in Boston, they are kept in separate pens and entirely apart from all other cattle and, therefore, are not exposed except possibly by some indirect or accidental means, to any disease with which cattle of the neighborhood may happen to be afflicted.

Foot and mouth disease is a contagious, constitutional disease of cattle, sheep, other ruminants and swine that is characterized by the development of vesicles or blisters upon the feet and in the mouth. These blisters are usually seen upon the coronary bands, about the heels and between the toes, inside the lips, upon the tongue and the upper border of the jaw. The effect of the eruption of the blisters is to cause the animal to refuse food, to become very stiff and lame and to lessen the flow of milk. After a day or two the vesicles break leaving a superficial sore which heals in from one to two weeks. Sometimes a similar eruption occurs upon the udder and this may cause a serious and dangerous complication by interfering with milking and thus setting up garget. During the course of the disease the afflicted animal loses weight very rapidly. Recovery occurs in nearly all cases but, after recovery, the animal is usually found to have been seriously damaged and to the extent, upon an average, of $20 to $25. The damage consists in loss of condition, permanent diminution in milk flow, garget, abortion or serious injury to the feet. Since an attack of foot and mouth disease does not confer immunity upon the animals that have passed through it, it happens in infected districts that these losses may occur as often as twice in a single year.

Foot and mouth disease is exceedingly contagious. It spreads with the greatest ease from place to place and from animal to animal.

When it is introduced into a herd it is exceedingly rare for a single animal to escape.

The amount of loss that may come from the existence of the disease is shown by a recent estimate made by a German authority who shews that during the last fourteen years foot and mouth disease has caused in Germany losses that amount to $250,000,000.

Fortunately, it has been possible, by co-operation between the authorities of the infected states and the United States Bureau of Animal Industry, to control the present outbreak of foot and mouth disease in the New England States, and there is now little reason to fear that it will escape to other parts of the country. The work of repression has fallen chiefly upon the federal authorities, supported by a special appropriation of $500,000.00 made by Congress for this purpose, and it is a matter for congratulation that this work has been so efficiently directed that it has been possible in so short a time to place the outbreak under such complete control.

Foot and mouth disease existed in one herd in Pennsylvania twenty-one years ago. This was a herd of imported cattle that were taken to a farm in an eastern county and quarantined there, as was the practice before the establishment of the federal quarantine stations. It was soon found that this herd was infected with foot and mouth diseases, but by keeping it strictly in quarantine the disease never escaped from the farm. Since that time, until recently, there has been no foot and mouth disease in the United States. It is possible that the present outbreak may be due to infectious materials, such as blankets, forage, wool, etc., imported either from South America or from Europe. It is not probable that the disease was brougnt in the United States by a living animal because such animals are examined and most of them are kept in quarantine and under observation for a period of about six to three months, depending upon their origin and species.

Expenditures.—For the fiscal year ending May 31, 1902, the State Live Stock Sanitary Board was allowed $40,000.00 for its general work of repressing infectious diseases of animals. The expenditures of this fund for the general purposes of the Board may be classified as follows: for tubercular cattle, $26,306.25; for glandered horses, $503; for inspecting tubercular cattle and herds, $3,326; for inspections for the purpose of suppressing diseases other than tuberculosis, and for vaccinating cattle against anthrax and blackleg, $3,402.54; for tags for marking cattle, for the expense of making tuberculin and shipping, $874.09; for cremating carcasses, serving quarantine notices and enforcing quarantines, for supplies, postage, office help and mis-

cellaneous expenses, $3,156.60; expenses for enforcing the law requiring the inspection of dairy cows and cattle for breeding purposes brought into Pennsylvania from other States, $2,431.52.

Respectfully submitted,

LEONARD PEARSON,

State Veterinarian.

REPORT OF THE ECONOMIC ZOOLOGIST.

Harrisburg, Pa., January 1, 1903.

Hon. John Hamilton, *Secretary of Agriculture:*

My Dear Sir: I have the honor to submit a review of the work of the Division of Zoology for the year ending December 31, 1902.

The general routine work of the office has consisted in the determination of material sent in, the mailing of bulletins, the acquisition of additional names of orchardists, farm gardeners and nurserymen to those already on file, the attention to the general correspondence connected with the Division and the work involved through the inspection of nurseries.

The interest taken by orchardists, nurserymen and others relative to the spread and control of the San José Scale and other injurious tree and kindred diseases is certainly very gratifying. The Division very frequently is in receipt of infested specimens, and it is apparent that persons interested along these lines are awakening to the fact, gained by actual experience, that individual effort has become essential in the treatment of tree diseases in order to successfully counteract the inevitable loss due to ignorance and carelessness. In order to grow trees which will produce good salable fruit, it is absolutely necessary to see that the tree is constantly kept in a healthy condition, by taking such measures as will effectually dispose of all injurious insects and tree diseases which may have a tendency to retard the good results to be obtained under favorable conditions. The fruit growing industry in Pennsylvania is of vast importance, and we find an ever increasing and a profitable market for choice fruits such as this State is capable of producing.

The Division has afforded assistance in every way possible to farmers and fruit growers, by placing at their disposal and disseminating such information, that will make possible for them to fully understand and put into practice such remedial measures as has been suggested. The San José Scale predominates to a very large extent, it being reported from nearly every portion of the State. Of course there are sections where it exists to a very small degree, while in other parts it is very prevalent, notably in eastern Pennsylvania, where fruit growing is carried on to a greater extent, and where the majority of the nurseries are located. The interest taken in the suppression of the San José Scale is widespread, the nurserymen particularly are doing efficient work for its eradication. Of course

the nurserymen are compelled by act of Assembly to dispose of all diseased stock, yet aside from that they are taking decided measures by the erection of fumigating plants and other means, to effectually stamp out the troublesome pests.

The year just closing has seen a decrease in the loss to farmers and market gardeners from injurious insects. Apparently the Hessian fly, the Augoumois moth, the cabbage worm and other usually abundant insect forms have for some reason been less plentiful. The Angoumois moth causes some loss to the wheat growers in the eastern counties, but through the information disseminated by this Division two years ago relating to this insect enemy, the loss has been very materially diminished judging from reports received from the infested territory. The tent caterpillars were not nearly so numerous as last year. The destructive work of this insect became so apparent to everybody that it led to a "general uprising" which resulted in the destruction of thousands of caterpillar nests all over the State, and such measures were taken, by the banding of trees and other means, that would effectually stop any further damage from this source. Insects injurious to the fruit crops of farmers still prevail such as the codling moth, curculio, lice, etc. But I am glad to state that very many farmers are beginning to see the good results obtained by spraying, and other remedial measures, which will eventually become more general as the outcome of such work becomes apparent.

The work of inspecting the nurseries, as required by act of Assembly, began August 1. Owing to the territory being so large, and more than one inspector could effectually cover in the limited time, it was deemed advisable by the Secretary to employ two additional inspectors in the persons of Profs. W. A. Buckhout and Geo. C. Butz, of The State College. The State was divided into three districts, namely, eastern, central and western. Prof. Butz made the inspections in the eastern district, Prof. Buckhout in the central and Mr. Enos B. Engle, the regular inspector, was given the western district. The inspectors completed their work in ample time to permit of the issuing of all certificates before the selling season opened. There were one hundred and ninety-seven inspections made during the year, seven of which were granted certificates expiring on July 31, 1902. For the year ending July 31, 1902, the inspectors visited one hundred and forty-seven nurseries, two of which were forest reservations covering many acres of land in Luzerne and Monroe counties; and while these are not nurseries proper, the inspection was made by Mr. Engle upon request of the owners and proprietors. This tract covers ten thousand acres on which is grown *Rhododendra-maxima* and these were granted certificates to sell stock after a thorough examination, as it was possible to make under the existing circumstances.

It was necessary to make one hundred and ninety inspections before the work was finished, of which total there were thirty-two second inspections, ten third, and one fourth, making in all forty-three having more than one inspection. There were seven of the nurseries refused certificates to sell or otherwise dispose of stock. With the exception of the forest reservations already referred to, the number of acres comprising the remaining one hundred and forty-five nurseries amounts to two thousand seven hundred and twenty and one-half acres. The inspection further shows that nurseries comprising one thousand seven hundred and thirty-eight and one-half acres are maintained in very good condition; five hundred and five acres in good condition; two hundred and twenty-four and one-fourth acres in fair condition; one hundred and seventy and three-fourth acres in indifferent condition; and the small total of seventy-seven acres to be in a poorly kept condition.

The following table shows the number of nurseries in each county:

Nursery List Showing Number and Acreage by Counties.

Counties.	Number of nurseries.	Number of acres.
Adams,	36	122¼
Allegheny,	4	36
Beaver,	2	38
Bedford,	3	7½
Berks,	1	0¾
Blair,	1	8
Bradford,	1	0¼
Bucks,	8	299
Butler,	1	30
Chester,	8	976¼
Clearfield,	2	0¾
Crawford,	1	20
Cumberland,	3	50¼
Dauphin,	3	9
Delaware,	7	31
Erie,	3	21¼
Fayette,	1	20
Franklin,	5	7¼
Huntingdon,	1	0½
Juniata,	1	15
Lackawanna,	1	1
Lancaster,	13	71½
Lawrence,	4	8
Lehigh,	1	22
Luzerne,	1	3
Lycoming,	1	1
Mercer,	4	8½
Mifflin,	1	1
Montgomery,	13	410
Northampton,	2	3½
Perry,	1	35
Philadelphia,	4	375
Somerset,	2	20
Venango,	1	6
Westmoreland,	1	8
York,	3	48
Total,	145	2,720½

Note.—Certificates have been issued for the sale and shipment of "Rododendron-maxima" from Luzerne county 8,000 acres and from Monroe county 2,000 acres.

The fact that there were only seven nurseries refused certificates to sell stock out of a total of one hundred and forty-five indicates a very satisfactory condition as far as relates to the presence of San José scale and injurious tree diseases. The majority of the nurserymen have fumigating plants on their premises, while others contemplate the erection of similar plants for the destruction of injurious insects and tree diseases.

There is no doubt that the law governing these matters is accomplishing much good, and the good results to be attained through the sale of nursery stock that is free of disease, will make itself evident in later years. If the distribution of injurious tree diseases can be prohibited through the nursery as an agency, then it is a very important step in the right direction, and will be of inestimable benefit, not only to the buyer of the nursery stock but to the nurserymen as well, and will place the State of Pennsylvania on the same level as that occupied by sister States which have stringent laws. This Division is also working in hearty co-operation with similar Divisions of other States, following very closely shipments of diseased stock from States having no laws governing this matter.

Appended to this report is a complete list of the nurserymen of the State, together with their postoffice address and the number of acres comprising each nursery.

Very respectfully,
BENJ. F. MacCARTNEY,
Economic Zoologist.

LIST OF NURSERYMEN IN THE STATE.

ADAMS COUNTY.

		Acres.
W. S. Adams,	Bendersville,	6
Battlefield Nurseries (C. A. & J. E. Stoner),	Gettysburg,	6½
Cornelius Bender,	Idaville,	½
H. L. Bream,	Cashtown,	2
Harry Cline,	Idaville,	1
E. W. Cook,	Aspers (Floradale),	3
William Cullyent,	Bendersville,	1
R. E. Elden,	Aspers,	2
Eli Garrettson,	Biglerville,	2
R. E. Garrettson,	Bendersville,	½
W. E. Grove,	York Springs,	13
H. J. Gulden,	Bendersville,	½
J. M. Hare,	Fairfield,	4
C. A. Hartman,	Arendtsville,	½
M. E. Hartman,	Cashtown,	4
N. M. Horner,	Gettysburg,	¼
O. P. House,	Bendersville,	7
C. L. Longsdorf,	Floradale,	20
William Myers,	Bendersville,	2
C. L. Osborn,	Floradale,	½
John H. Peters,	Bendersville,	3
C. E. Porter,	Bendersville,	4
Mrs. Angelina Sheely,	Bendersville,	2
H. W. Sowers,	Latimore,	1½
William Starner,	Arendtsville,	½
Storrick & Hartman,	Gettysburg,	3

ADAMS COUNTY—Continued.

		Acres.
John P. Stover,	Cashtown,	4
A. D. Taylor,	Arendtsville,	4
C. J. Tyson,	Floradale,	2
Dr. G. P. Weaver,	New Oxford,	2
J. J. Weigle,	Ariosa,	4
B. F. Wilson,	Floradale,	1½
Charles J. Wilson,	Mummasburg,	4
William & Kuntz,	York Springs,	2
A. S. Wright,	Bendersville,	7
George E. Wright,	Floradale,	1½
Total,		122¼

ALLEGHENY COUNTY.

B. A. Elliott,	Allegheny (Station 10),	3
J. Wilkinson Elliott,	Springdale,	15
G. R. Elliott,	Allegheny (Station 10),	8
J. B. Murdock & Co., No. 510 Smithfield street,	Pittsburg,	10
Total,		36

BEAVER COUNTY.

A. R. Goodwin,	Industry,	8
Mackall Bros.,	Beaver,	30
Total,		38

BEDFORD COUNTY.

S. B. Amos,	Bedford,	2½
Jacob Barnhart,	Bedford,	3
Austin Wright,	Alum Bank,	2
Total,		7½

BERKS COUNTY.

William Stoudt,	Centreport,	¾

BLAIR COUNTY.

Isaac H. Kemp,	East Freedom,	8

BRADFORD COUNTY.

Morgan Evans,	Neath,	¼

BUCKS COUNTY.

Horace Janney,	Newtown,	7
D. Landreths' Sons, No. 21 South Sixth street,	Bristol,	10
Joseph L. Lovett,	Emilie,	6
Samuel C. Moon,	Morrisville,	50
The W. H. Moon Co.,	Morrisville,	200
Henry Palmer,	Langhorne,	4
Somerton Nurseries,	Somerton,	20
Josiah G. Youngkin,	Richlandtown,	2
Total,		299

BUTLER COUNTY.

Pierce Bros.,	Butler,	30

CHESTER COUNTY.

George Achelis,	West Chester,	200
The Conard & Jones Co.,	Westgrove,	4
The Dingee & Conard Co.,	Westgrove,	4
Hoopes Bros. & Thomas,	West Chester,	600
J. F. Keech	Oxford,	¼
Rakestraw & Pyle,	Willowdale,	150
J. B. Reif,	Spring City,	2
Josiah A. Roberts,	Malvern,	16
Total,		976¼

CLEARFIELD COUNTY.

		Acres.
Grove L. Tyler,	DuBois,	¼
J. D. Wright,	Clearfield,	½
Total,		¾

CRAWFORD COUNTY.

Prudential Orchard Co.,	Shermansville,	20

CUMBERLAND COUNTY.

John Peters & Co.,	Uriah,	50
D. C. Rupp,	Shiremanstown,	¼
Woodville Nurseries,	Uriah,	*
Total,		50¼

DAUPHIN COUNTY.

Rife & Ulrich Nursery Co.,	Royalton,	4
Calvin P. Scholl,	Fisherville,	4
Gilbert Troutman,	Millersburg,	1
Total,		9

DELAWARE COUNTY.

John G. Gardner,	Villa Nova,	7
M. F. Hannum,	Concordville,	1
Conrad Lamm,	Lansdowne,	2
The Oak Nursery Co. (P. C. Supplee, Manager),	Collingdale,	12
W. L. Rementer,	Lansdowne,	2
J. J. Styer,	Concordville,	3
Stuart Wood (400 Chestnut st., Philadelphia),	Brookthorpe,	7
Total,		34

ERIE COUNTY.

C. E. Archibald,	Girard,	¼
A. F. Young,	North East,	10
L. G. Young,	North East,	14
Total,		24¼

FAYETTE COUNTY.

J. Sterling & Son,	Masontown,	20

FRANKLIN COUNTY.

Byers Bros.,	Chambersburg,	¼
Philip Fisher,	Chambersburg,	¼
A. M. Good,	Waynesboro,	½
J. W. Hefflefinger,	Green Village,	6
William P. Reed,	Chambersburg,	¼
Total,		7¼

HUNTINGDON COUNTY.

J. Peter Snyder,	Huntingdon,	½

JUNIATA COUNTY.

Landis & Wagner,	McCullough's Mills,	15

LACKAWANNA COUNTY.

E. J. Hull,	Olyphant,	1

LANCASTER COUNTY.

		Acres.
W. P. Bolton,	Liberty Square,	4
Maurice Brinton,	Christiana,	20
Calvin Cooper,	Bird-in-Hand,	3
John G. Engle,	Marietta,	6
H. M. Engle & Son,	Marietta,	2
John H. Gamber,	New Providence,	2
H. H. Harnish,	Huber,	8
Daniel D. Herr,	Lancaster,	5
S. R. Hess & Son,	Ephrata,	2
John Kready,	Mount Joy,	½
Wilson Kready,	Mount Joy,	1
O. W. Laushey,	Bird-in-Hand,	4
A. W. Root & Bro.,	Manheim,	14
Total,		71½

LAWRENCE COUNTY.

W. T. & F. P. Butz,	New Castle,	2
D. W. Fisher,	New Wilmington,	2
J. W. Hayes,	Bessemer,	3
A. S. Moore,	New Castle,	1
Total,		8

LEHIGH COUNTY.

W. B. K. Johnson,	Allentown,	22

LUZERNE COUNTY.

P. Sutton,	Exeter,	3

"Rhododendron-Maxima."

Manning Bros. (1101-4 Tremont Building, Boston, Mass.),	New White Haven,	8,000

LYCOMING COUNTY.

Evendon Bros.,	Williamsport,	1

MERCER COUNTY.

J. L. Hoobler,	Chess,	3
Mable Nursery Co. (S. E. Bortz),	Transfer,	1
J. W. Nelson,	Indian Run,	3
C. L. Unger,	Chess,	1½
Total,		8½

MIFFLIN COUNTY.

John S. Mohler,	Maitland,	1

MONROE COUNTY.

"Rhododendron-Maxima."

Manning Bros. (1101-4 Tremont Building, Boston, Mass.),	Cresco,	2,000

MONTGOMERY COUNTY.

Rudolph Brohm,	Hatfield,	½
C. Haennis' Sons,	McKinley,	½
Robert C. Haines Co.,	Cheltenham,	6
J. B. Heckler,	Lansdale,	4
Chris. Koehler,	Fox Chase,	2
Thomas Meehan & Sons, Inc.,	Dreshertown,	200
James Krewson & Sons,	Cheltenham,	12
Jacob B. Moore,	Hatfield,	5
John Rieg,	Jenkintown,	10
William Sturzebecker,	Lansdale,	2
J. W. Thomas & Son,	King-of-Prussia,	65
Charles H. Wilson,	Gladwynne,	3
Thaddeus N. Yates & Co. (7336 Germantown ave., Phila.),	North Wales,	100
Total,		410

NORTHAMPTON COUNTY.

		Acres.
W. M. Benninger,	Benningers,	1½
Theodore Roth,	Nazareth,	2
Total,		3½

PERRY COUNTY.

George A. Wagner & Co.,	Alinda,	35

PHILADELPHIA COUNTY.

Andorra Nurseries (W. W. Harper, Prop.),	Chestnut Hill,	300
Thomas Meehan & Sons, Inc.,	Germantown,	65
John Stephenson's Son,	Oak Lane,	4
Thaddeus N. Yates & Co. (7356 Germantown ave.),	Germantown,	6
Total,		375

SOMERSET COUNTY.

H. C. Pfeiffer & Bro.,	Gladdens,	2
Village Nurseries (Harry B. Kemp, Prop.),	Harnedsville,	18
Total,		20

VENANGO COUNTY.

H. S. Sutton & Son,	Franklin,	6

WESTMORELAND COUNTY.

John McAdams,	Mt. Pleasant,	8

YORK COUNTY.

W. S. Newcomer,	Glenrock,	3
J. G. Patterson & Son,	Stewartstown,	42
George E. Stein,	East Prospect,	3
Total,		48

PAPERS READ AT THE ANNUAL MEETING

OF THE

STATE BOARD OF AGRICULTURE,

HELD AT

HARRISBURG, PA., JANUARY 22 AND 23, 1902.

PAPERS READ AT THE ANNUAL MEETING OF THE STATE BOARD OF AGRICULTURE, HELD AT HARRISBURG, PA., JANUARY 22 AND 23, 1902.

ANNUAL ADDRESS OF THE SANITARIAN.

By BENJAMIN LEE, M. D., *Philadelphia, Pa.*

Mr. President and Members of the State Board of Agriculture of Pennsylvania:

Gentlemen: If the position which I have the honor to hold in relation to this Board, and I desire to say that I deem the honor a distinguished one, if, I say, this position is to be something more than merely honorary, it must be made so by furnishing you information on the only subject with which I can claim intimate familiarity, namely; the preservation of your health and that of your families.

I cannot talk to you about mangel-wurtzels and manures, fantails and fertilizers, corn and cucumbers, ruta-bagas and rotation of crops, or potatoes and pigs; but I can give you points on health and hygiene. Health, the greatest of all earthly blessings; hygiene, the science and art of securing and prepetuating that blessing. He who spake "as never man spake" said, "They that be whole need not a physician but they that are sick." I suppose that the meaning he desired to convey was, "They who consider themselves whole, that is in good health, do not feel the need of a physician. but they who know that they are sick." There are many people both in the city and country who think themselves whole but who carry within them the seeds of disease or damaged organs. These people do not appreciate their need of a physician, but some day they drop dead of heart disease, or fall in the convulsions of Bright's disease, or are stricken with apoplexy as by a bolt from Heaven out of the clear sky, or sink to death in galloping consumption. All of these people do need a physician, but they do not know it. They may have some little premonition of impending trouble but they explain it away, and will not allow either to their friends or themselves that there is anything seriously the matter with them. They "are not going to fool

away either their time or their money on doctors." Too often they adopt a compromise and do fool away their money on quack medicines; while, if they would manfully face the music, and obtain the advice of a competent physician when their first sense of discomfort begins, he could detect the hidden source of danger and give them such advice as to the conduct of their daily lives, their food and raiment, their meat and drink, their labor and their rest, their working places and their dwelling places, as would stay the progress of the incipient disease and greatly add to their capacity for work, increase their comfort and prolong their lives. The majority of them indeed do not only feel no gratitude to the physician, who informs them that their condition is one which will result, if unchecked, in premature death; they actually feel a certain amount of resentment against him for daring to make such an unpleasant suggestion. All this, which as I have already acknowledged has no especial pertinence to the Agriculturist, more than to the dweller in cities, as a prelude, and to establish a parallel along which we may work to illustrate our second thought, which does have a distinct and special reference to the agriculturist and to the resident of the village and small town.

During the period since I studied medicine there has grown up a distinct branch of the science known as Preventive Medicine or State Medicine, the object of which is to elevate the standard of health in communities or what is known as "public health." Now just in proportion as a community or a certain class of the population considers itself whole, it fails to appreciate the need for State Medicine. Inhabitants of large cities have it forced upon them by the conditions which always accompany the crowding of a large number of people into a small space that certain of these conditions endanger the health of all who come within the reach of their influence; that certain regulations must be adopted to control these conditions and that the regulations are of no manner of use unless there is some one whose duty it is to enforce them. The gradual crystallization of these lines of thought results in what is known as a board of health; and no city which makes the slightest pretensions to intelligence and civilization is to day without a health authority, whether under the name of board of health, bureau of health or commissioner of health. But the moment we get out into the country all this is changed. The farmer and villager meet us at once with the assertion, made in good faith, "we are whole." "We need no physician. Our region, our village, is famed for healthfulness. What need have we for State Medicine? We have no use for a board of health." Wrathful indignation breaks forth against the unfortunate who ventures to make the suggestion that it would be possible by any human device or regulation to prevent one early death or prolong one

life in a locality so famed for its salubrity. And so, when one of your chief men is stricken down by a disease which State Medicine has proclaimed and proven to be preventable and therefore unnecessary; when you drop the hot tear over the pallid or disfigured face in the little coffin; when with bowed head you follow to the grave the partner of your life and your affections, all victims of contagious disease, you fold your hands and say "It is the Lord's doing, we must bend in meek submission to His will." And this you call being religious. What kind of a religion is this that charges the Almighty, the loving and tender Father in Heaven, with the result of your own carelessness and negligence! Your own wilful ignorance of His laws.

The assumption that, in proportion to population, the diseases which State Medicine declares to be dangerous to the public health, and which boards of health are established to combat and prevent, are less prevalent in the country and country villages than in large cities cannot be proven. Typhoid fever, as many of you have had occasion to know to your grief and sorrow, is often a visitant at the farm house; scarlet fever and diphtheria are only too well known in the rural town and the mountain hamlet. Mining settlements and lumber camps have been hot beds of small-pox during the epidemics of the past three years. As a rule the large towns have become infected from the country, and the villages, and not the country and village from the city. And yet the first message which the State Board of Health receives from these sparsely settled districts, sometimes by mail, sometimes by telegram, sometimes by telephone, is "Small-pox here. No board of health. What are we to do?" Why is there no board of health? The State Legislature, now some years since, authorized the school directors in every township to organize as a board of health, adopt regulations, enforce the State law for the prevention of contagious and infectious diseases and employ agents for this purpose. Why has this law been allowed to remain to so great an extent a dead letter on the statute book? To use the idiom of the day, "it is up to you," gentlemen of the State Board of Agriculture, you who represent the brains and intelligence of the districts from which you are sent, you who are leaders in your respective communities, you who collectively wield a greater influence in the State than any other association, craft or calling in the body politic, to answer this question, and I leave it with you.

Let me briefly detain you to listen to a few facts and figures in connection with the present prevalence of small-pox in the State. More than three years ago, in the month of September, 1898, two soldiers, belonging to Battery C, U. S. V., returning from Porto Rico, came to East Vincent township, Chester county, bringing small-pox with them. Ten cases developed in the township, with two deaths,

and the disease was communicated to Spring City, Chester county, and to Royersford, Montgomery county. By the energetic action of the Medical Inspector of the State Board of Health for Chester county, Dr. J. G. Shoemaker, in whose recent death the State and the Board have sustained a most serious loss, the disease was effectually stamped out. But the circumstance was sufficient to indicate to the State Board that similar cases must constantly occur with the return of large bodies of troops from the West Indies where this disease always prevailed under Spanish rule, without the slightest attempt at restriction, and steps were at once taken to inform all boards of health that it was their duty to prepare for the inevitable epidemic. With the exception of the large cities of the State, with well organized and experienced boards, this warning was "as the idle winds which they regarded not." A few school boards organized as boards of health, and they have since had reason to congratulate themselves on their wisdom. But as a rule, throughout the rural districts nothing was done. The prophesied epidemic, starting naturally in Florida where the great majority of the troops were disembarked, travelled steadily up along the coast, entering this State from lumber camps in Virginia and Maryland. In one of the counties of the southern tier it prevailed throughout the mountainous, sparsely settled, districts for many months unrestricted, and in fact rarely recognized, until it reached the most important borough in the county, where, as there was a board of health, its true character was determined and the State Board was notified. From this starting point, in the rural districts it spread all over the State, prevailing principally in farm houses, mining villages and lumber camps. By the wisdom of the State Legislature, a fund of $50,000 had been created several years before, on which the State Board of Health, with permission of the Governor, the State Treasurer, and the Auditor General, could draw in cases of emergency, and by the judicious use of a small portion of this fund, the State Board was able to establish quarantines and furnish vaccination in the rural districts with great promptness, so that at the end of twenty months, although 3,194 cases had occurred, and twenty-nine counties had been invaded, with 178 centres of infection, it was able to declare that the disease was entirely stamped out.

Three months later, however, two children from Colorado, where small-pox was then extensively prevailing, came to a borough near the Capital of the State bringing the infection with them. The disease quickly spread to Harrisburg and to neighboring hamlets and villages, and eventually over the entire State. It was also subsequently brought in from other States. Owing to unfortunate dissensions in the last Legislature, the emergency fund appears to have been overlooked, so that the State Board is now entirely without

means to carry on the work of prevention as in the previous outbreak, and the disease is still spreading, especially in townships, new centres of infection being reported every few days. All that the State Board can do under the circumstances is to use its best efforts to induce the school boards to organize as boards of health and rigidly enforce the law of 1895, for the restriction of communicable diseases. They have ample authority, but little money. The law authorizes them to employ a salaried sanitary agent, but makes no provision for other expenses. They should therefore at once confer with the county commissioners and poor directors and make arrangements with them for bearing their appropriate share of the pecuniary burden which must be assumed, for nothing is more certain than that a small-pox epidemic cannot be successfully managed without the free expenditure of money.

But to return to our figures. The two children from Colorado arrived in January, 1901, about twelve months ago. During that time there have been reported to the Board 2,689 cases; of these 1,905 have occurred in cities and boroughs, and 984 in unincorporated rural districts. The population of the cities and boroughs concerned is 1,959,510 while that of the rural population is 44,722; so that the number of cases in the cities should have been forty-three times as great as that in the townships, in point of fact it was only about two and two-thirds as great. From this we make the deduction that, so far as small-pox is concerned, at the present time there has been, comparing the populations of infected townships with those of infected cities, at least fourteen times as great a prevalence of the disease in the townships as in the cities and boroughs. This statement strikes you as preposterous. And yet a moment's consideration ought to convince you that it is simply what might be expected. In the city, take Philadelphia, Pittsburg or Harrisburg for instance, the moment a case of suspicious eruptive disease is discovered by a physician, he notifies the health authorities, who send an expert to determine the diagnosis. Should the case prove to be small-pox, the house is placarded, and guards are established. Within two hours the case has been removed to the Municipal Hospital where the best medical skill is available for its care and recovery, and the inmates of the house have all been vaccinated. The house is absolutely sealed up. No one comes out or goes in, and this strict quarantine is kept up until the danger point for the inmates has passed. When the house has been thoroughly disinfected they are allowed to go out and mingle with the public. But this is not all. The school authorities, if there is a child in the house attending school, are at once notified. The children are dismissed and the school closed and not opened again until it has been thoroughly disinfected. In addition to this, all of the school children have been already vaccinated in obedience to the State law.

Now contrast the condition in the townships. If the patient is not very sick the probability is, that to avoid expense, no physician is called in, and no precautions are taken. His friends drop in to see him. The children, unvaccinated, as is the case with most of their school-fellows, go to school every day as usual. At the end of two weeks some of the children of the family are taken sick and at the end of another week some of the neighbors begin to develop the same symptoms. It begins to dawn on the minds of the community that an infectious and contagious disease is spreading among them, and one of the families thinks it well to call in a doctor. His suspicions are aroused. Other doctors are called to see the case and still other doctors see other cases. Then the comedy of what may turn out to be a tragedy begins. Not one of these doctors has probably ever seen a case of small-pox. The doctor who discovered the first case and suspected its true nature is set at naught and ridiculed if not threatened with personal violence. Dr. Bolus does not hesitate to pronounce it to be chicken-pox, and will stake his reputation on it. Dr. Pilule calls it *impetigo contagiosa* and rolls the grand sounding name off his tongue with much satisfaction. Dr. Physick says that its nothing in the world but Cuban itch, unaware of the fact that Cuban itch was the name given to small-pox by our soldier boys in Cuba in jest. Dr. Aloes pronounces it with still greater acumen, Philippine measles. Dr. Veterin is inclined to the belief that it is swine-pox. Dr. Homeo entitles it *la grippe* complicated with eruptive tendencies. Dr. Jalap swears that it is German measles and nothing more. Dr. Paregoric who has seen a fatal case with dark spots on the skin is quite sure that it is Petechial fever. And so while the doctors disagree, the infection travels merrily from farm house to farm house, from village to hamlet until it at last reaches a borough or city with a board of health. A consultation is at once called, but, while a difference of opinion still manifests itself, finally, that is to say at the end of an hour, not of several months, the opinion of Dr. Wiseman prevails, to the effect, first that as the case is a suspicious one it should be at once strictly quarantined, and, secondly, that, as like his brethren, he is unable to make up his mind on the spur of the moment as to the exact nature of the disease, it is desirable to summon an expert to whose decision the question may be referred. The State Board of Health is at once telegraphed so to that effect. Within twenty-four hours the expert has reached the spot, the case is decided to be true small-pox of a mild type, and all necessary precautions are taken. The infection is stopped right then and there, possibly not another case occurring in the borough. Is it any wonder then that small-pox prevails to a very much greater extent in proportion to population in townships than in incorporated cities and boroughs which are compelled to maintain boards of health?

But you say, "It costs money to establish quarantines, and townships are poor." The first statement I admit. There is nothing worth having in this fallen world that does not cost money, but the plea of poverty I do not admit. In proportion to population and comparing the relative demands for expenditure, I believe that the residents of a township are just as well able to pay a reasonable health tax, as those of a city. And in the end it would prove a saving, just as the maintenance of a fire department does in any community. Should you not be too much out of patience with this long homily to be willing to continue me as your Sanitarian, I shall hope to preach you another sermon next year on the text, "Its an ill bird that fouls its own nest," and show you that there are other conditions besides the prevalence of contagious diseases which make it imperative that no township should be without a board of health.

DAIRY HYGIENE.

BY DR. M. E. CONARD, *Westgrove, Pa.*

In discussing the importance of dairy hygiene, we are confronted by the many prejudiced impressions in the minds of people who seem to think that we are advocating an entirely new thought and principle, possibly, for self gratification only, which, if put into practice, must entail burdensome inconvenience and expense upon the producer of dairy products, which bring in no adequate return or compensation. If this view of the subject is a correct one, the life of the new departure will be short, and we shall soon return to the "good old days" of the wooden milk bucket and earthen milk pan, with all their accompanying adjuncts in the dairy industry.

However, modern life has its needs, and those needs show little respect for illogical prejudice. The days when every man could go out to the forests and streams and kill what food he needed are past. Our food supply is now often drawn from remote sections of the country. The farmer of one-half century ago, driving his cattle along dusty miles of road to market, finds a curious counterpart in the modern stock raiser, who sends his cattle a thousand miles to the stock yards, without leaving the comforts of his own home for a single night, and receives the returns for their sale at his own door.

The conditions surrounding the rearing of live stock, and the marketing of their products are matters of the greatest importance to our railroads as well as to the consuming public. They frequently demand local or State investigation, and are often a topic for international discussion. Bad health amongst our live stock, and the consequent unhealthfulness of their products, affects our general foreign trade; for it is recognized that man and the lower animals in a greater or less degree affect each other, and that some diseases can be transmitted from man to brute, and from brute to man. An facts that can reduce the spread of contagion are, therefore, of the highest importance to man, and those engaged in increasing and disseminating our knowledge of them should be classed as public benefactors.

The commercial conditions of to-day have called into existence hundreds of crowded towns and cities, in which wholesome food is an absolute necessity, and in which unwholesome or infected food

means a pestilence; consequently, any movement that insures the production of better meat, purer milk, better food in general, means fewer cases of sickness, a smaller percentage of deaths—results which should receive the hearty and liberal co-operation of all in their attainment. Probably there never was a time when there was more attention paid to the production of pure foods, particularly for the weaker portion of our race—the infants and invalids—than now. It is reasonable that this should be the case, for there never was a time within our knowledge when the causes of the contamination of foods was so well understood as now, with possibly much more to come. A more accurate knowledge of the appearance, life history, and favorite environment of many of the unseen species of animal and vegetable life has revealed to us many simple facts that explain away mysterious conditions of foods which were previously accepted as inevitable, but are now easily understood and controlled. Objectionable conditions arising from bacterial growth and multiplication, can often be remedied by preventing this increase, and desirable conditions or changes in foods can often be produced by favoring the presence of certain forms of germ life just as we destroy from our fields all forms of vegetable life except the particular kind we plant, and desire to grow for crops. It is just as objectionable to have "weed" bacteria growing in our foods as it is to have the larger weeds growing in our fields.

The conditions above referred to apply to almost all kinds of human food, but especially to dairy products, for the reason that the product of the cow is an animal food, and possesses within itself all of the elements needful to develop all parts of the growing animal. As milk and butter are generally eaten without cooking, and without in any way destroying the bacterial life contained therein, we see the need for their being produced under such conditions as will insure the least possible risk from invasion by injurious germ life. Now milk is one of the best culture mediums for germ life we have; this fact verifies the importance of our subject.

As hygiene means the rational and methodical use of everything essential to the preservation of health, and, by implication, life, dairy hygiene must mean the proper and rational preparation of such dairy products as we consume for food, so that when taken into the stomach they may produce only such results as were intended by nature they should, and be replete with all the life and strength-giving elements required for our best growth and development. Nature in her wisdom has provided that milk should be consumed in the most hygienic manner possible, and that is without its ever seeing daylight or coming into contact with the outside air. This is ideal hygiene. But if such protection as this is needful to have milk in a purely hygienic condition, we may well perceive how far we fall short

of the ideal when we expose it to stable air loaded with dust, to the falling hairs from the animal's coat, and to many other unsanitary conditions, during its commercial life in passing from the udder of the healthy cow to the stomach of the consumer, possibly one hundred or more miles away.

If the laws of hygiene are so strictly followed by nature in guarding the health of the young of animals, why should we be indifferent to the importance of their application when it becomes necessary for man to use the milk of the cow as a commercial food product for the sustenance of that portion of humanity who need the best and purest the market can afford. Do we not blunder to the verge of sinning when we go on with its production from day to day under conditions that are far from being conducive to the result demanded by the age—a food product that shall be ideally wholesome and nutritious, and imparting only health and vigor to the consumer.

It is not a new thought or principle that is involved in dairy hygiene, but on old principle or law of nature under a comparatively new name. We oftentimes shy at names before we understand their true meaning, and the sense in which they are meant to be used. We have always practiced dairy hygiene, so far as its principles have been understood, by giving our dairy products such care and protection as we thought necessary. We did as we were taught, but the teaching did not convey the idea that there was dirt which the naked eye could not discern, or which could not be removed by the ordinary strainer. In short, we applied the principle according to the knowledge we possessed. We did not know so much of the unseen world in the past as we do now—that world teeming with life which has been revealed to us by the aid of the microscope and the processes of the laboratory. We did not know that particles of dust could be the means of conveying from one place to another the germs of fermentation, or those of disease, the deadliness of the one or both depending upon their origin.

The application of the principles of sanitation, or hygiene, must depend wholly upon our knowledge of the possible and more probable sources of contamination, for without such knowledge we cannot guard the channels through which contamination or infection is likely to course, and it is a well established fact that we cannot by our senses, or otherwise, detect the presence of germs in milk or other food until they have produced in them the consequent changes peculiar to their species. When it becomes necessary to prevent the entrance of such germs into our foods, we must adopt such means in their handling as will not expose them to conditions to germ life, for where germs are present, they will surely find their way to the soil most fertile for their growth.

If bacteria are known to abound in dust, dirt, or the hairy coat of cattle, or the soiled hands of a workman, or in his clothing, or in poorly washed dairy utensils, or in an atmosphere which has been contaminated from manure piles in a heating condition, or in stagnant pools of water, it becomes our moral duty to our fellow man to remove such conditions from our dairy premises. We must not think to tolerate them just because of our knowledge that their harmful influence upon our milk and butter can be arrested by the addition of chemicals in the shape of preservatives. Let us remember that milk is a complete food, containing all the elements necessary to the growth of bone, muscle, hair, nails, and, in fact, every part of the body, and that these elements or constituents of milk are found in the right proportion for the proper development of the body, hence anything done by us which results in a change of its constituency just to that extent interferes with Nature's plans. If we take from a food, we lessen its nourishing power; if we add to it, we change its qualities in accordance with the character of the substance added. If we add pure water, we simply make the milk less nourishing; if we add sugar or starch, we increase that constituent of the milk in proportion to the amount added. But if we add a preservative of any kind we thereby add something that is injurious to life, because it is used as a poison, i. e., it is introduced to destroy the life of those germs or micro-organisms which by their growth and multiplication cause the many changes so common in milk. If a preservative is poisonous to small fry it must be proportionally so to larger animals. If not injurious to life it is not a preservative. Even cold is injurious to life, and it is for that reason it becomes so valuable in the preservation of milk, meat, etc., and it would be just as injurious to health were it taken into the stomach, and kept there, as other preservatives are. But it is the only preservative known that can be added to food and maintained there until the food is to be consumed, and then effectually removed, leaving no trace of bad effect. It is Nature's only preservative; all others come to the ingenuity of man. If food were taken into the stomach at a temperature of 40 degrees Fahrenheit, and that temperature maintained, the result would be prompt and serious. Cold does just what other preservatives are meant to do—merely arrest germ growth. Upon its removal the germs may again become active. And so a reduction of temperature does not actually poison or destroy germ life, but places around it conditions that temporarily arrest its growth and development. Now if it were possible to so handle and protect milk during its commercial life as to totally prevent the introduction of any germ life whatsoever, and were the cow from which the milk is drawn perfectly healthy, we can readily see that it would never go sour. But such a degree of perfection and cleanliness is not practicable,

at least within the limits of our present knowledge. And yet it is very desirable that we should approach as nearly as possible those conditions which will admit of our prolonging the commercial life of milk, so that it can be consumed with safety by the babe or invalid at a distance remote from the source of supply.

This realization of the importance of an intelligent application of practical dairy hygiene has made Denmark famous throughout the world for her fine milk, cheese and butter, and has enabled her to capture the best markets for the last named of these products.

It is a foregone conclusion that the more sanitary care of milk will reduce the percentage of loss in its commercial handling, be it shipped to the city markets or sold at the near-by creamery. So the problem before us resolves itself into a financial proposition, as well as one involving the health of the consuming public. Whether such care as we are contending for will pay or not is no longer an open question, for it has passed the experimental stage, and is being answered in the affirmative by actual experience in many of our up-to-date, or, I might more properly say, "pioneer" dairies. It is well known by all of our best informed dairymen that if milk is properly handled during the first two hours after being drawn from the cow, the souring process is very much retarded.

It is not the purpose of this paper to discuss methods of applying dairy hygiene, but we think that if every creameryman or milk vender would receive only such milk at a remunerative price as was known to be handled according to our best knowledge of practical hygiene, and all other milk at a lower price, the object lesson would be a good one; for we know from personal experience that the percentage of saving to the sanitary operator would compensate him well for his extra labor and expense, besides placing him on a higher moral plane, and introducing him into a more progressive frame of mind; while the man who preferred to cling to the good (?) old way, and take the lower price for so much of his product as he succeeded in getting to market in a salable condition, would soon see the folly of his ways, and enter the ranks of his more thrifty neighbor.

The question may arise—"What constitutes practical dairy hygiene?" We would answer: A knowledge that the cows are free from disease; a well lighted and well ventilated stable, with floors and troughs of such material as will not readily absorb liquid manure, and with sufficient fall for effective drainage; promptly cleaned daily, and well dusted over with land plaster or South Carolina rock; the side walls and ceilings should be smooth, and light in color, so as to prevent the collection of dust; the cows should be clean; brushed off daily, and, if necessary, have the thighs and hips clipped, to prevent the collection of manure; the milking

should be done by cleanly persons, with dry hands, and having the soiled clothes covered with an outer garment, to prevent the shedding of dirt particles into the milking pail. The prompt removal of all milk from the stable, and its being immediately strained, and cooled to a temperature of 50 degrees F., in an atmosphere free from dust and all taint of the stable; if not to be shipped immediately it should be stored in ice, so that the above temperature may be maintained. The utmost cleanliness should be maintained at all times, particularly with the dairy utensils, which, after a thorough washing with warm water and soap, should always be sterilized with live steam or boiling water, and then be exposed to the sunshine and pure air.

We have not asked for the expenditure of much additional money or labor, but simply for the intelligent use of what we already command. Practical dairy hygiene calls for good, healthy cows, practical inexpensive stables, and rational methods; that is all. The methods pursued, however, are of the greatest importance. No man has a moral right, nor should he have the legal right to sell or hand to his fellow men, be he milk vendor or creameryman, the product of any dairy that does not receive the best sanitary care that his means and conditions will admit of. The law punishes us for allowing noxious weeds to grow where they can invade our neighbor's crops, but the man who dumps contaminated milk into the creamery tank, thereby impairing the quality of the whole batch—probably the output of a half dozen or more farms—goes "scot-free," and ridicules the so-called "fancy farmer" who is trying to do his best in the direction of improvement, but is handicapped for want of a chance to deliver his goods undefiled. Pay the man who adopts rational sanitary methods in the dairy a fair price for his products, or, rather, give him the advantage of the contingent fund that every creameryman is now compelled to set apart to meet the inevitable losses under the old slip-shod methods, and then pay the other fellow a proportionally lower price to meet losses, and the importance of dairy hygiene will be made evident to all, in terms easily understood.

FOOD ADULTERATION IN PENNSYLVANIA.

BY DR. WM. FREAR, *State College, Pa.*

It has been requested that I prepare for your consideration a paper presenting the subject of food adulteration from the chemist's point of view.

It has been said that the manufacture of foods and the control of food commerce is the battle-ground of chemists. Without at all failing to appreciate the importance of honest and capable executive action, of alert detective service, of specialized and skilful legal advice, of the experience and investigating abilities of the physician and physiologist, it is true that the discovery of adulterations, the determination of their nature and amount, and the exposition of the essential facts of adulteration to the court and jury are functions with which the control chemist is charged.

There was a time when the housewife, by the simple process of testing the solubility of her salt or sugar, could detect the presence of the added sand. It is said, too, that the Mayor of Guildford used to appoint official ale-testors who were wont to test the ale not only by the taste, but pouring a portion of it upon the bench before the inn, sat in their leathern breeches upon the bench; if they adhered when attempting to arise, it was considered plain that "mine host," lead by unfair means, increased the density of his ale.

The day has passed when such simple tests will much avail in detecting current adulterations. The development of modern, synthetic chemistry has opened vast possibilities to the imitator and adulterator. It is but a few decades since the formation of the organic food stuffs was considered to be possible only under the influence and by the direct agency of the vital force inherent in the plant and animal; but in 1828, Wöhler, by heating the corbonate of ammonia, produced area, the chief nitrogenous waste-product of the animal body; sometime later. Berthellot made formic acid, which is widely distributed in nature, by the simple process of exposing caustic potash to the action of carbon monoxid, the gas that burns with a blue flame in our coal stoves. These discoveries proved that the vital force of the chemist's brain and the ordinary chemical agencies are capable of performing much, if not all of the elaboration of ma-

terials—not their building into tissue and their awakening to life—that had formerly been regarded as exclusively the function of another agency; numerous workers have since spent their efforts in this field. As a result, not only have many of the simpler organic substances of nature been produced in the laboratory, but a host of entirely new compounds have been built up. It has been thought that perhaps the principal components of foods might, because of their complexity, defy the highest skill of the chemist to unravel the secret of their true nature and, having taken them apart, to put them together again. But, within the last decade, Fischar accomplished the synthesis of the glucoses a group to which our starch and fruit-sugars belong; Perthellot, some years ago showed that fats can be made in the laboratory and many investigators are working upon the synthesis of the albuminoids. Such has been the progress in this field of chemical activity that one of the greatest of French chemists predicted, not long since, that by the opening of another century, civilized lands would no longer be dependent upon the farm and the transportation lines for food, but would have it made in factories of their own from the cheapest material—air, water, coal, etc.

This prediction is not one over which this generation of food-producers needs to be particularly concerned as affecting the staples of life. But the manufactures of the more expensive dainties and luxuries find their fields of activity already invaded.

The reception with which these new products are met, is not wholly cordial. The average man regards them as very interesting triumphs of science properly finding a place in the museums among other curious things. If they are to be eaten, he would prefer that others make the first experiment. If he is interested in the production of the substances whose market they may threaten, he is less dispassionate than the consumer of the brands. Meeting such opposition, the makers of the substitutes too often turn to fraudulent means of securing a market, justifying their action by the specious pleas that the consumer is prejudiced and the manufacturer of the standard material is selfish and a seeker of class legislation, and that for these reasons it is not unjust to gain for their products by deceit the sale which their own merits will not at once win for them. It is easy to overlook the right which a buyer has to receive the article for which he asks and is willing to pay, even though his selection may be guided by prejudice. We sometimes forget on the other hand the truth which history teaches, that if the new invention is useful, while we may prevent its violent disturbance of existing conditions by the use of wise public regulations, we shall not prevent its constantly finding its place and remaining as a permanent addition to the resources of the race.

The new problems constantly introducing themselves to the con-

trol chemist as the result of such increased knowledge and skill at the command of the dishonest, are made more numerous by the rapid changes in the manner of preparing and keeping articles of food. The modern grocery store exhibits to the buyer's eye little that is edible; instead, a great array of cans, boxes, cartons, jars and tumblers, beautifully labelled, greet the gaze. If he is thus prevented from handling the food that later comers will buy, he is also prevented from seeing, until the package is opened at his own home, the article he buys. Many a fraud lurks under the cover of a beautiful label.

Every age and every class has dishonest men. Pilse says of the latter part of the twelfth century, "False rights, false measures, false pretences of all kinds were the instruments of commerce most generally in use. No buyer would trust the word of a seller, and there was hardly any class in which a man might not with reason suspect that his neighbor intended to rob or even to murder him." Men are better than that to-day. Not so many will defraud their neighbors. But, on the other hand, the resources of the fraudulently disposed have been wonderfully increased. Leaving to others the presentation of the statistical, administrative and legal aspects of the subject, let us consider some examples of the various types of adulteration occurring within our State boundaries, and some of the problems with which the food chemist must deal. In this survey, no attempt is made to present a full list of discovered adulterations, but simply to consider certain interesting cases, typifying the various forms of adulteration.

These types are well defined in the Pure Food act of 1895, in addition to which there are special laws with reference to milk and cream, renovated butter and oleomargarine, cheese, lard, evaporated apples and other apple products, fruit juices and vinegar; the Pure Food act follows the precedent of the English food and drug act in defining the terms "food" and "adulteration," and, in most States that have acted in reference to food adulteration, the same general method of legislation has been pursued. Under this act, new abuses can be quickly reached, but the burden of establishing its definitions and standards, and of proving the injurious character of adulterants, where such injury is alleged in the indictment, rests more heavily upon the prosecution. The special laws commonly express the definitions and often establish standards for the substances with which they severally deal and, in most cases, make especial regulations for the commerce therein and provide different penalties from those specified by the general act. In all cases, however, the adulteration belongs to one or more of the types indicated in the latter act.

This act prohibits (1) the addition of materials so as to lower or depreciate or injuriously effect the quality, strength and purity; (2) the substitution, in whole or in part, of any inferior or cheaper sub-

stance—this differing from the first offence in that it evidently refers to the more specific cases of complete substitution, or of the partial replacement of a standard article by one of like purpose, but of inferior use or commercial value; (3) the reduction of quality or strength of an article by abstraction from it of any valuable or necessary ingredient; (4) imitating another article or selling something else under its name; (5) the sale of diseased, infected or decomposed, tainted or rotten food—or of milk coming from a diseased animal; (6) treatment of a material in such manner as to conceal damage or inferiority, of whatever kind; (7) the addition of a poisonous or injurious ingredient. In the foregoing test of types, no attempt has been made to adhere to the full vestige of the act, but to express the gift of its classification of typical offences.

As an earlier paragraph has pointed out, the responsibility detecting the adulteration rests with the chemist. Where the adulterant is a substance entirely foreign to the food, its detection and usually its quantitative determination are more or less readily accomplished. But where the adulteration is such as to be apparent only in some change in the proportion of the normal constituents of the food, its detection is far more difficult. In some instances, it is true, that both in the case of manufactured articles and of natural products, the law or some authoritative trade agreement has fixed the standard and made the definition. There are more cases where the chemist is obliged to reach his own definition by careful consultation of legitimate trade interests and a full survey of the commodities in the market, and to establish his standards of comparison. So far as natural products are concerned, the work of standardization is difficult, for these products, even when pure, are found to vary widely. It is not hard in the case of common articles to strike an average of composition; but it requires wide knowledge of the causes and extent of variation, and a patient consideration of all interests, to establish such a minimum standard as shall, on the one hand, not expose the public too freely to the rapacity of the fraudulent, nor, on the other hand, to greatly increase the probabilities of injustice to the innocent producer. The association of Official Agricultural Chemists of the United States, to whose membership all State food control chemists are ex-officio entitled, has taken up the systematic consideration of the needful definitions and standards, in consultation with the various interests affected; it is urged that their work, which has the cordial support of the Secretary of Agriculture of the United States, may be helpful to the conduct of food control throughout the Union.

Among the adulterations of the first class, which chiefly consists in the addition of valueless materials, there are few requiring particular mention. Of the staple foods, milk is probably the only one that

is at all extensively subject to such adulteration. The occurrence of watering is established either by the observed reduction of the solids not fat or of the ash in the milk; sometimes if the sample is fairly fresh, it can be established by the presence of nitrates which occur almost universally in rain water and in flowing streams, but have never been found in pure milk. The writer has had recently to contend with the objection that the addition of water to milk is not an offence under this clause of the Pure Food act, because water, being itself a normal constituent of milk, can not be regarded as an impurity when added without the intervention of the cow.

Next in importance, because of the volume of trade affected, is the watering of vinegar. This is detected either by a deficiency in valuable or indication constituents, such as acids, solids or ash, when compared either with the legally established standard for distilled vinegars, or with a fair, accepted minimum for fruit vinegars. In case of fruit vinegars, watering is also detectible in some cases, because of changes which the water produces in the qualities of vinegar ash.

The addition of worthless materials, such as ground cocoanut shells, cracker crumbs, charcoal, etc., to spices is sometimes found, but the enforcement of the Pure Food act appears to have greatly diminished this practice.

Cream of tartar probably stands next to milk and vinegar in the frequency with which it is subject to this type of adulteration, though marked improvement is shown in this material also since the establishment of the food control; the most common, worthless substances added are gypsum and terra albo. Partial substitution, an adulteration of the second type, is most common in the case of jellies, preserves, etc., as well as of spices and vanilla extract.

In the case of fruit preparations, starch and gelatine afford the gelatinous basis of the cheaper articles. Glucose, an entirely legitimate sweetening material which is quite well established as a harmless and, indeed, valuable food, is the common sweetening agent of these preparations, though some cane sugar is usually present. The objection to the substitution of glucose for cane sugar without notice lies in its inferior sweetening and preservative power, as compared with cane sugar, and its much greater cheapness. The flavoring materials used in the cheapest goods are commonly tartaric or citric acid, some artificial fruit ethers and artificial coloring matters. Such use of coloring matters without notice is doubtless indictable also as an offence of the sixth type, since they make the preparation look better than its really is.

A somewhat higher grade of jellies is made in which cheap apple jelly is the basis of the preparation, to which other flavoring materials and artificial colors are added in order that the substance

may pass for peach, currant or raspberry jelly. The cheap apple jelly is often made from the apple pomace cider obtained by repressing; it lacks the apple flavor, for the most part, and is often decidedly astringent.

Sausage is another staple article of diet that is subject to adulteration of this class. The writer has recently examined a number of bologna sausage to which starch has been added in considerable quantities.

Maple syrup has been extensively adulterated. A little of the cheap, rank-flavored maple-sugar of the late runs, is made to spread its flavor through a large volume of glucose syrup or dissolved cane sugar. The polariscope shows at once, the former adulteration; but the latter is more difficult of detection since the pure sugar of the maple is chemically the same as that made from the sugar cane or the sugar-but. Detection depending in such case, upon the proportion in which the accompanying malic acid and ash are found in the syrup.

Honey is also subject to extensive adulteration, in which even the bees may be made to participate. Honey has well been defined as the nectar of flowers gathered and secreted by bees. Its table value lies not so much in the sweetness, as in the fine flavors of the nectar. It is often adulterated by the substitution, in part, of glucose; sometimes cane-sugar syrup is used instead. The polariscope usually shows such adulteration clearly, but small substitutions can not always be so easily discovered. For bees feeding in pine forests, produce a honey behaving in some respects like that made by adding glucose. Some cane-sugar is present in nectar and is carried over, a small portion of it, unchanged with the honey. Bees feeding near sugar refineries have been found in Europe to produce honey exceptionally rich in this constituent. The honey produced by the summer feeding of bees with cane-sugar lacks the nectar flavors, and is not to be regarded as true honey.

Another very frequent case of substitution occurs in vanilla extract, where the stronger flavored *coumarin* is used in place of part of the vanillin coumarin is made from the plant-deer tongue and from carbolic acid; it is the active odoriforms and flavoring substance of the Tonka bran. While not known to be injurious, it is much less expensive than vanillin and of inferior flavor.

Substitutions also occur among the spices; clove stems are mixed with cloves; the stem contains only about one-fourth as much of the valuable essential oil as the whole cloves. Pepper hulls, left as a residue in the manufacture of white pepper are very frequently added to ground black pepper; the hull is not without spice properties, but is quite inferior to the white spice. Starch is added to mustard and wheat flour to buckwheat, often with the plea that

the housewife herself makes such mixture when she purchases either of these materials; observe, however, that the vendor does not seem particular to notify his customers of the admixture.

As instances of common adulteration by abstraction of valuable substances, may be mentioned the skimming of milk before its sale; for its detection the change in the proportions between the milk constituents must be relied upon. The removal of much of the oil of cloves from the white cloves and the subsequent sale of the spent buds, is a matter of some frequency. The removal of an excessive degree, of the cocoa-butter from cocoa is to be regarded as belonging to this class of offences. On the other hand, no objection is urged to the removal of some of the fixed oil of mustard since that is not the valuable constituent of the condiment and the removal is believed to increase the keeping quality of the ground mustard.

At one time, spent tea, composed of the leaves that have been steeped and thus exhausted of most of their soluble materials, was observed upon our markets. The present conditions of the import trade are believed to have put an end to the extensive practice of this adulteration.

The adulteration by imitation and misbranding is one of the most prolific methods of raud. Cottonseed, harmless but very cheap, parades as the finest imported olive oil; this is of comparatively infrequent occurrence to-day, however; white acid phosphate or a mixture of gypsum and tartaric acid are sold as cream of tartar. Fruit juices, so-called, are made from sugar, compound ethers, acid, coal tar colors. Dr. Jenkins exhibited to me, some time ago, twenty-five or thirty differently dyed stripes of wool, the variegated truth of which were due to coal-tar dyes, but came severally from as many glasses of soda water "with genuine fruit syrups."

Fruit flavors are scarcely imitated by the artificial ethers or compound ethers, made from acetic, butyric or valoric acid and either ordinary alcohol or the fusel oil obtained as a by-product in the manufacture of cheap whiskey.

Lemon extract instead of being composed of a solution of five parts by volume of pure oil of lemon in ninety-five of strong alcohol (ninety-two per cent.) is imitated by a solution of much less than one per cent. of citral in twenty-five to forty per cent. alcohol, sometimes made more dense with sugar, and colored a beautiful yellow with coal-tar colors, sometimes with the poisonous water-colors. Citral forms, it is true, the most active flavoring material of oil of lemon, which contains between six and seven per cent. of this aldehyde; but the latter material can be much more cheaply made from East India oil of lemon grass, which contains upward of eighty per cent.

The most conspicuous members of this group are oleomargarine

and renovated butter. Of the former I will not speak since I understand the consideration of this substitute has been more specifically assigned to another.

The term renovated butter is applied to butter which, after having reached such an advanced stage of decomposition as has led to its rejection for human consumption, has been treated in such a manner as to remove the decomposed materials most offensive to taste and smell. In the days of our grandmothers, when butter was packed in summer for use during the following winter, an occasional lot of butter that had gotten a little beyond the point of acceptability was washed with a solution of baking soda, and thereby relieved somewhat of its disagreeable flavor and odor. The processes now in vogue in establishments where renovation is carried out on a large scale, are somewhat more complex. The butter, gathered without regard to its degree of decomposition or exposure to filth, is melted in a tank; the decomposing curd the products of decomposition of the milk sugar, the mineral salts and the water settle to the bottom, while the fat is drawn off to an aerating tank. The process of aeration is chiefly relied upon for removal of taint. The process is variously conducted, blowing, pumping and spraying of the melted fats being employed, one or all of them, to secure thorough contact of the fat with the air. When the major part of the taint is removed, the partially deodorized fat is conducted into ripened skim-milk, milk or cream, usually the former, by which some positive, desirable flavors are imported, for it is now quite well established that instead of butter flavors being wholly due to the fat, they are in very considerable degree due to the products made by the action of the ripening bacteria upon the milk sugar and possibly upon its nitrogenous materials. Having been cooled in contact with the ripened milk, the fat is gathered and then worked as fresh butter is.

The manufacture of this renovated article has made very rapid advances in the imitation of fresh butter. Formerly a very watery, salvy article was made, whose water content decisively proclaimed its nature. To-day, there is little difference in this respect between the fresh and the renovated article.

The detection of this substance has proven a difficult problem. It is, in fact, excessively rancid butter from which the bad flavor and odor have been largely removed. It is, furthermore, extremely susceptible to renewed decomposition whereby the bad flavor and odor reappear.

To secure a better understanding of the principles involved, a consideration of the nature of rancidity is requisite. It is desirable to distinguish between the rancidity that occurs in the pure fat, separated from the curd and salt; and that which occurs in the butter, containing the curd, salt and water.

In the case of the pure butter- fat, the changes are purely chemical, since fat does not sustain bacterial life. Pure fat in the absence of light and air, keeps indefinitely, but undergoes a progressive series of changes when exposed to light and air. The nature of these changes has been studied by many chemists, the investigations of Dr. C. A. Browne in the laboratory of The Pennsylvania Agricultural Experiment Station being probably the most extensive. These investigations show that the fat first exhibits a tendency to bleach, to become tallowy in flavor and odor and later, to assume a sharp flavor and pungent odor. The chemical changes accompanying these physical modifications are chiefly the result of an oxidation of the oleic acid of the butter-fat; for the quantity of oleic acid steadily decreases as rancidity increases. The acidity of the fat increases with the rancidity, though not necessarily, in proportion to the development of undesirable odor and flavor. It was formerly supposed that the acidity and the undesirable qualities of rancid butter were due to the liberation of free butyric acid; but this is now shown to be an incorrect surmise. Butyric acid is water-soluble, while the acidity developed early in the formation of rancid butter is proven to be due to insoluble fatty acids. The bad odor and flavor may be due to aldehydes, which develop in larger quantity as rancidity increases, and are like acids, formed by oxidation. The glycerol, which is an essential part of all fats, is likewise diminished as rancidity advances. Schmid suggests that the aldehydes found in rancid butter-fats are formed from the glycerols. Scala, however, found that pure oleic acid developed these compounds when exposed to the air; he separated the aldehyde from rancid olive oil and identified it as oenanthylic aldehyde, which he regards as the principal malodorous material of all rancid fats. Browne has shown that these aldehydes are changed, probably to volatile acids, in the process of determining the volatile fatty acid number of the rancid fats. In the later stages of rancidity, the volatile acids in the fats themselves rapidly increase. As a consequence of both facts, the volatile fatty acid number of pure butter-fat increases as rancidity advances.

The chemical changes suffered by the fat when it turns rancid in contact with the water, casein, milk, sugar, salt and ash present in all butters, have not been so fully studied. They are, in part, of the same nature as in the case of the pure fat. Bacterial life and the development of moulds are, however, possible in the presence of the casein, sugar and ash, and the former is probably present in all cases. One fact, clearly established by recent investigations is, that when the rancid butter becames mouldy, the quantity of volatile fatty acids decreases; renovated butters, sold as such, commonly show a low volatile acid number, while their total acidity is high.

As the fat becomes more rancid, whether in the pure condition or

in contact with the other constituents of butter, it dissolves more easily in acetic acid and in alcohol, the solvent employed in the Valenta and Crismer tests respectively.

The fat of a renovated butter naturally exhibits most, if not all, of the ear-marks of a rancid butter, especially the high acidity and low Valenta or Crismer number and usually, a low volatile acid number. When freshly made it differs from rancid butter in possessing less of the disagreeable odor and flavor which rendered the rancid article unsalable; no satisfactory chemical measure of the difference between renovated and rancid butters in the quantities of aldehydes they contain, has yet been found. Until recently, renovated butters have exhibited a distinct tendency to sputter like oleomargarine when melted, and to crystallize as the result of their heating and cooling; but these characteristics are less possible in many samples of late make.

Doolittle and Hess have suggested that, since renovated butter is commonly rechurned out of whole milk or skim-milk, it will usually contain more albumen than butter churned from ripened cream. This difference is sometimes exhibited in such degree as to form a positive means of identification of the renovated butter, but not in all cases.

In the absence of chemical tests conclusive in all cases, the difficulty of a perfect control of the commerce in renovated butter by the usual methods of regulation is clearly apparent and the need is evident if keeping a record of the manufacture and distribution of this commodity.

Concerning the effect of renovated butter upon health, there are few recorded dates. Most persons experience more or less nausea upon the use of strongly rancid butter, and Arata found that very old butter produced vomiting, pain of the bowels and purging. How far these ill-effects are reduced by renovation has not been determined by exact test. The commonly noted lack of care to prevent the contact of the rancid butter used for renovation from filth and excessive decay, constitutes a fair ground of question as to the wholesome nature of the article made therefrom by a purely mechanical method of renovation. The temperature at which butter melts is entirely too low to secure the sterilization or even the pasteurization of the melted fat.

The sale of decayed or decomposed foods has not been so prominent as to call for special notice. Abuses of this kind are often so apparent as to be self-regulating, as in the case of rotten vegetables, tainted meats or "swell-head" canned goods. So far as diseased meats are concerned, the services of the veterinarian rather than the chemist are required to prevent their reaching the market; the same is true of the prevention of the sale of milk from diseased animals.

Our various municipal boards of health are doing a useful work in the sanitary inspection of the dairy farms from which their respective cities derive their milk supply.

Of the sixth type, the use of artificial colors, acids and flavors to conceal the inferiority of low grade jellies consisting in part of the fruits whose names they bear, may be mentioned as an example; the occasionally observed use of turmeric to impart a yellow color to mustard diluted with starch is of the same nature. Coatings and facings formerly somewhat used to conceal the inferior nature of tea and of raw coffee, are rarely found to-day.

The deliberate addition of poisons to foods for the purpose of enhancing their commercial value is, happily, of relatively infrequent occurrence. The use of copper salts to preserve the natural green tint of peas and gherkins, and of poisonous coal-tar dyes to color a great variety of food-stuffs, is probably the most common offense of this class. In most cases of this kind, there is rarely a violent poisoning; the danger lies chiefly in the cumulative or continuous effects of the powerful materials. The convenience of the maker or vendor is not a sufficient ground for his use of materials that jeopardize in any way the health and lives of the public.

The use of certain powerful antiseptics now widely employed, even in staple foods, as preservatives, is an abuse belonging to this type of adulteratives. The use in food of any such antiseptic can be considered as permissible only when the article can not be preserved for a reasonable length of time by the best modern methods of preparation and handling; and should, even in such case, be closely controlled as to the antiseptic permitted, its quantity and with fair warning of its presence to the buyer.

From the foregoing illustrations, it is evident that many of the abuses of the past have been reduced, but that much still remains to be done; indeed, that only unceasing vigilance and increasing skill will avail in this combat with the cupidity and cunning of those who prey upon their fellows, or are too weak to avoid an evil example in the stress of competition.

Much too, remains to be done in the painstaking and extensive study of the sanitary effects of the numerous chemical substances of recent origin that are seeking entrance into our lists of food materials. The united skill and experience of the physician, physiologist and chemist must be applied to this study and it is much to be hoped that existing American experience in this field may, in some way, be brought together and that Congress may make adequate financial provision for the work of this kind with which it has already charged the Secretary of Agriculture.

THE POLLUTION OF DOMESTIC WELLS.

BY PROF. C. B. COCHRAN, *West Chester, Pa.*

As our country is gradually becoming more thickly settled and the sources of pollution of springs, streams and lakes are constantly increasing, the problem of obtaining a pure water supply for towns and cities is becoming more and more difficult of solution.

Since the character of the water supply of a city or town is a matter of great importance to a large and continually increasing number of people, skillful investigation attended with the expenditure of much time, labor and money is usually given to a solution of this question. If, in any case, the problem is not satisfactorily solved the newspapers or other periodicals are very apt to assume the responsibility of calling public attention to the impure character of the water supply. In this way the inhabitants of a city or large town usually acquire some knowledge as regard the quality of the water furnished for their daily consumption.

On the other hand, the subject of the water supply of country homes is almost completely ignored by the public press. And, as a consequence, the average individual deprived of this common means of information forms the very natural conclusion that the water from a well or spring located in the country is the very emblem of purity and counts himself fortunate in being able to obtain his water supply from such a source.

Why should the water from this country well be impure? It receives the surface drainage of no village, town or city. No sewers or factory wastes or other similar sources of pollution sometimes found contaminating public water supplies, can pollute it. Furthermore, it is a universally admitted truth that water percolating through the earth in regions remote from thickly inhabitated areas is usually wholesome and palatable.

While these facts argue strongly in favor of the sanitary condition of country wells and springs we have yet to consider the effect of such possible sources of pollution as barn-yard, privy vault and household wastes.

Assuming that no surface drainage from any of these sources can reach the well, we are still in ignorance as to what may take place below the surface. The impression that water, no matter how badly

polluted, will purify itself by percolating through a few yards of earth has led to the commission of many blunders. Entirely too much confidence has been placed and is still placed in the power of the earth to purify water by filtration.

In order to illustrate this fact I propose to compare the results of analyses of water from polluted wells with those of pure waters from the same localities. In order to understand the significance of these results it will be necessary first, to explain the meaning of the terms used in the report of a chemical analysis of water.

A chemical analysis of water for sanitary purposes is simply a means of obtaining comparative measurements of the amount of filth which has been dissolved by the water and the extent of its decomposition.

In the report of a water analysis we usually find figures representing the amounts of the following substances expressed either in parts per million or in parts per hundred thousand; chlorine, nitrogen as nitrites, nitrogen as nitrates, nitrogen as ammonia, organic nitrogen, and total solids. Sometimes temporary and permanent hardness, oxygen absorbed and other data are also added.

A bacteriological examination may be made consisting of an estimation of the number of bacteria in one c. c. of the water and a search for such bacilli as occur in the intestines of man and the lower animals (bacillus coli communis or other bacilli of the colon group). From the data furnished by such an analysis and an examination of the surroundings of the water supply, an intelligent judgment can be formed as to the sanitary condition of the water.

Chlorine usually exists in water combined with sodium in the form of common salt. As sewage and the tissues and excreta of man and many of the domestic animals are rich in salt, any excess of chlorine above the amount found in the purest water of a given locality is generally due to contamination with animal matter and its presence in excess unless it can be otherwise accounted for is regarded as an indication of pollution of a dangerous character

Nitrogen is a constituent of many organic compounds especially those of animal origin. The figure given under nitrogen by permanganate is regarded as a measure of the amount of decomposing organic matter in the sample.

Nitrates are formed by the decomposition and complete oxidation of nitrogenous organic matter. Nitrogen in this condition represents the final stage in the putrefaction of animal matter. In the final disposition by the processes of nature of organic matter rich in nitrogen; nitrites represent an intervening stage between ammonia and nitrates. Their presence in water may be due either to the partial oxidation of organic nitrogen or to the abstraction of oxygen

from nitrates by decomposing organic matter. In either case nitrogen as nitrites in water is considered a serious indication by sanitary chemists.

The term total solids refers to the residue left by evaporation of a given quantity of water. It includes both mineral and organic matter and varies greatly both in character and quantity, even in pure waters, depending on the character of the rocks through which it has passed. While a general standard of purity is used to some extent by chemists, it is generally acknowledged that a local standard based upon a knowledge of the composition of many samples of water in a given region is more satisfactory. By comparing the results of his analysis with the local standard of purity the chemist forms an opinion as to the sanitary condition of a given sample of water.

In the following table is given the results of the analysis of a number of samples of water taken from shallow wells, springs and streams within a radius of twelve miles of West Chester. From the results of these analyses and from the location and surroundings of these waters, I believe them to represent a fair standard of purity for the region just named:

Pure Water.

Number.	Source.	Chlorine.	Nitrogen as nitrites.	Nitrogen as nitrates.	Nitrogen as ammonia.	Nitrogen by permanganate.	Total solids.
1	Stream,	2.5	00	1.32	0.018	0.08	54.8
2	Stream,	2.8	00	2.7	0.028	0.092	60.00
3	Spring,	2.8	00	0.3	0.016	0.014	30.00
4	Stream,	2.7	Trace.	0.75	0.05	0.06	127.00
5	Well,	2.7	00	0.25	0.028	0.066	54.00
6	Stream,	4.0	00	1.00	0.028	0.086	77.00
7	Spring,	2.0	00	2.75	0.066	0.112	77.00
8	Well,	2.5	00	3.50	0.044	0.088	77.00
9	Well,	2.5	00	5.00	Trace.	0.005	70.00
10	Well,	2.48	00	2.80	0.01	0.052	54.00
11	Stream,	3.10	00	2.80	0.008	0.032	80.00
12	Spring,	3.00	00	4.00	0.01	0.012	120.00
13	Spring,	2.40	00	1.00	0.058	0.052	41.00
14	Stream,	2.8	00	2.2	0.044	0.072	64.00

Samples numbered 4 and 12 are exceptionally high in total solids. This is due to the fact that these samples were taken from a limestone region and are consequently hard waters.

Judging from the results of these analyses I am led to fix the standard for this locality as follows: Chlorine 4 or less. Nitrogen as nitrites or, nitrogen as nitrates below 4. Nitrogen as NH_3, below .08. Nitrogen by alkaline permanganate 0.1 or less. Total solids usually

below 70 except when the water comes from a limestone region when a larger amount will be expected. The above figures are all expressed in parts per million.

An examination of a number of wells and one spring used as the water supply for country homes gave results indicated in the following table. The last number in the table shows the character of the water in a small stream heavily charged with sewage from the borough of West Chester:

Impure Water.

Number.	Source.	Chlorine.	Nitrogen as nitrites.	Nitrogen as nitrates.	Nitrogen as ammonia.	Nitrogen as permanganate.	Total solids.
1	Well,	49.00	Abundant.	....	0.032	0.260	393.00
2	Well,	14.00	00	8.00	0.0065	0.041	156.00
3	Spring,	4.00	Trace.	6.00	0.025	0.060	100.00
4	Well,	14.50	00.05	21.7	0.124	0.146	....
5	Well,	30.00	00.625	3.5	0.84	0.38	171.00
6	Well,	48.40	0.3	16.7	0.035	0.072	202.00
7	Well,	3.2	0.008	2.00	0.12	0.224	132.00
8	Well,	27.44	Heavy trace.	13.00	0.116	0.22	....
9	Well,	55.00	0.11	15.00	0.084	0.14	303.00
10	Well,	69.00	00.02	20.00	0.064	0.196	540.00
11	Well,	6.5	Trace.	2.75	0.4	0.41	142.00
12	Well,	12.4	Present.	10.00	0.018	0.016	161.00
13	Well,	19.6	None.	10.00	0.02	0.052	208.00
14	Well,	8.00	Considerable.	12.5	Trace.	0.068	126.00
15	Well,	....	....	....	....	....	1,045.00
16	Well,	10.4	None.	6.5	0.005	0.024	138.00
17	Well,	5.2	None.	5.5	0.016	0.018	113.00
18	Well,	7.6	0.4	2.0	1.128	0.296	108.00
19	....	250.00	00	00	24.08	0.704	....

A comparison of these results with those given in the table representing the unpolluted waters reveals a very decided contrast, and shows at a glance the remarkable extent of contamination in the water supply of the farm house. Such a high degree of pollution as this is not to be found in the water supply of any city or town so far as my knowledge goes. It is very fortunate for many of those who dwell in the country that the consumption of water containing fecal matter or other filth in solution does not always produce fatal results or even cause disease. Such waters as those represented in the table are, however, a constant menace to health and even to life and should unhesitatingly be condemned for household use. Several of these analyses were made at the request of physicians who regarded the water supply as the cause of typhoid fever or other intestinal disturbances and in three instances at least deaths resulted.

In every instance in which I have been able to inspect the premises, I have found no sources of pollution except those for which the in-

mates of the house were directly responsible and which might have been avoided by the outlay of very little money.

For the sake of convenience the well is located near the house, oftentimes under the same roof. At no great distance is the privy vault, or in case the house is supplied with a water closet in doors the cesspool may be found within 30 or 40 feet from the well. The waste water from the house is either thrown directly upon the ground in the neighborhood of the kitchen or at the most carried but a short distance away by pipes and then left to find, own channels.

In case one well is used for both house and barn it is frequently located somewhere between the two buildings. If it escapes pollution from the sources just mentioned it is in danger of contamination from the barnyard. There seems to be an impression more or less general that if the privy vault is 30 feet or more from the well there is no danger of contaminating the water, particularly if the surface of the earth slopes from the well toward the cesspool. To illustrate the fallacy of such an opinion, I will select two cases from the analysis given in the table. Sample No. 18 was taken from a well in the country. The only apparent source of contamination within a quarter of a mile or more was a privy vault between 50 and 60 feet from the well. The results of the examination of this sample indicate an exceedingly foud condition and points directly to contamination with matter of animal origin. There is no doubt whatever that the privy vault just mentioned was the source from which this water received its pollution.

In this connection, sample No. 15 shows results that are still more instructive. The well from which this sample was taken is located on a farm property about eight miles from West Chester. The owner of this well had at various times dumped a quantity of sulphate of zinc in a depression in the earth between one and two hundred feet from the well. The water was found to contain 1-10 of one per cent. (1,000 parts per million) of zinc sulphate, an amount sufficient to render the water unfit for domestic use.

The pollution of the water supply is doubtlessly the most serious sanitary evil in connection with country homes and it is an evil which has existed throughout all past time. The existence of such an evil as this is in some cases probably the result of ignorance, in other of indifference or perhaps a combination of both. Oftentimes it is difficult matter to convincé a man that a well that has been used by himself during his entire lifetime and perhaps his ancestors before him, is supplying a water unfit for household use. He will point to the fact of its long continued use as evidence of wholesome character of the water, and as additional evidence that there can be no pollution from cesspools or barnyards, he will call attention

to the fact that the well stands on higher ground than either. He forgets the fact that it is underground not surface drainage that has polluted the well. While it is true that the movements of the ground water frequently follow more or less closely the course of the surface water yet such is by no means always the case. It is entirely unsafe to attempt to draw any conclusion with regard to the movements of the ground water in a small area by observing the surface drainage. Oftentimes the movement of the underground water is in exactly the opposite direction from the surface water. Sometimes very good evidence can be obtained as to the probable course taken by the subsoil water, from an inspection of the geological formation in the neighborhood of the well. Frequently, however, soil and vegetation completely conceal all evidence as to probable course of the underground water. In some localities where the geological formation and the dip of the strata are uniform, an opinion can be formed as to the course of the underground water, though nothing can be seen of this formation in the immediate vicinity of the well. On the other hand, in some localities, as for example in the vicinity of West Chester, the structure of the earth is so complex that frequently very little information can be gained in regard to the movements of the subsoil water by surface inspection. The country about West Chester is composed either of igneous rocks or very highly metamorphosed sedimentary rocks, without evident stratification and cut in different directions by numerous dikes and fissure veins.

In order to illustrate how a well may be contaminated by a neighboring source of pollution, let us imagine a cesspool six feet deep placed within forty feet of a well, say fifty feet deep. The ground slopes from the well toward the privy the difference in elevation being possibly five feet or more.

Under such circumstances as these the bottom of the cesspool will be about forty feet above the level of the water in the well and consequently above permanent ground water. If the subsoil is homogeneous and permeable in character the water from the cesspool will drain downward and outward from this point in every direction. The earth will gradually become saturated with organic matter and polluted water will be carried to the well before it has descended to the general level of the ground water. If in addition to this the movement of the ground water is toward the well, still more serious pollution will result. Should the dip of the rock be toward the well or should it be impermeable and filled with fissure veins, the danger of pollution is still greater. In many cases where the earth is composed of compact rock cut by fissure veins or other cracks it is difficult to tell where the water of a well or spring may come from. In such cases pollution may be carried a long distance.

At this writing I have in mind a certain farm, the water supplies

of which are interesting both from a sanitary and a geological standpoint. The distance between the house and barn on this farm is a trifle more than 200 feet. There is a well at the house and another in the barn. Between the house and the barn is the beginning of a little valley. At the head of this valley is the privy vault, and also a large pigpen capable of accommodating thirty or forty pigs. Although this place is located on very high ground, yet at the center of this little valley, only a short distance from its head, ground water is reached at the depth of three or four feet. As this ground water moves down the valley, it gradually comes nearer and nearer to the surface which it finally reaches, forming a spring. In spite of the fact that the ground water of this little valley carries with it the drainage from house, privy vault, pigpen, and barnyard, it has been frequently suggested as the source of supply for house and barn, and it was with some difficulty that the inmates of the house were restrained from so using it. The slight depth at which ground water is here reached indicates that the area drained is quite limited and that an impervious rock lies near the surface. The water furnished by the well at the house is exceedingly hard while that from the barn well is soft. These two wells and the spring although located within less than 100 yards from one another nevertheless receive their water supply from three different sources. In case of the spring it seems possible to trace the course of the water from the clouds until it issues from the earth, but in case of the wells it is difficult to account for the difference in the character of water.

This pollution of country wells is not only an abomination from an aesthetic and sanitary standpoint but it is also an extravagant waste when viewed from a financial standpoint. The actual money value for fertilizing purposes of the barnyard and household wastes should serve as a sufficient incentive to abolish all danger of contaminating the well water. If a shallow water tight depression were provided for barnyard manure and stable runnings, and the dry earth closet adopted for household use, the existing sanitary evil would not only be abolished but their entire manurial value would be saved. These substances together with the wood ashes and the refuse of the kitchen should all find their place as plant foods for coming crops.

A NECESSITY OF A BETTER PREPARATION FOR FARM WORK.

By Prof. G. C. Watson, *State College, Pa.*

Since the earliest time of which we have any written history of Agriculture, attempts have been made to improve the conditions of the husbandman through the improvement of the materials with which he has to deal. It is probable that attempts were made to improve the condition of the husbandman much earlier than any time of which we have record. In the light of modern times these attempts undoubtedly would appear insignificant, but the mere fact that these attempts were made at this early date, and that similar attempts have been made continually until the present time, should teach us that the efforts which we are now putting forth are only a continuation of the great plan which our ancestors have followed for centuries of time. We sometimes take much credit to ourselves for the progress that we have made and oftentimes overestimate the results which we obtain and underestimate the value of the work of others who endeavored to make improvements throughout the earlier years of agricultural advancement. Pioneer work is hard work and usually is without commensurate results. Those who preceded us did much to their credit which would have started us far in advance of our actual beginning if we could have made the best use of all that had been gained. In the past, actual progress has been slow and has been marked by series of advances and retrogressions. Great gains have been made only to be lost again. The fact that apparently unnecessary losses have occurred and are now occurring, through the lack of a better knowledge of the materials with which the agriculturist deals presented to the writer the theme for this paper.

It is probably as true to-day as at any time in the past, that noteworthy advances are being made along various lines of agricultural work and that the advantages thus gained by the promoters or improvers are being rapidly dissipated by the uninformed who attempt to take charge of the improvement but who do not have sufficient knowledge to make the best of their opportunities.

It is recognized that, for generations, the foremost manipulators have erected worthy monuments for themselves in the shape of valu-

able materials which have been improved in their hands as the result of a life's work of untiring vigilance coupled with the highest art known in the field within which they were working. A few agriculturists have stood prominently above the masses in nearly every generation for centuries. Their whole energy seems to have been given to make something better. Their life's work was devoted to the improvement of the material which their fellow men must use and which subsequent generations must use and perhaps depend upon for their sustenance.

Improvements have been made along many lines of work, but marked improvements have been made by only a small number of persons. In the majority of cases the improvements which were obtained at a great cost of time, labor, skill and oftentimes at a great sacrifice, have not been maintained but have been dissipated within a much shorter time than was required to effect the improvement. The history of agriculture shows too plainly that the downward road is often the swiftest and the most certain. The comparatively few improvers who have worked long and hard to achieve something of a permanent value, of necessity have become skilled and expert in their chosen lines of work. These men have left the results of their skill and lifelong toil in the hands of the unskilled who could not appreciate the advantages gained, and consequently lost in a short time that which had been won by the master minds and which could only be won by those of superior intelligence and foresight.

Farmers are continually endeavoring to secure increased yields through skill in breeding and through various manipulations which should not require a proportionate increase in the outlay of labor or money. In other words, they are continually striving to secure larger returns for the necessary outlay. The grain farmer, the fruit grower, and the stock breeder are each trying to increase the value of the medium or machine which he is using to convert the crude material into an acceptable merchantable article. The farmer who has been raising wheat for many years with an average yield of perhaps fifteen or eighteen bushels per acre realizes that his profits would be increased if the average yield per acre could be increased but a few bushels. It is evident that it would be advantageous to secure an increased production without increasing materially the cost of production. He therefore tries to secure a variety of grain that will bring to him larger returns without increasing in any way his expense account. He hears of the greater yields secured by his neighbors who claim to be cultivating superior varieties. The yields which they obtain apparently bear out the assertion that they are cultivating improved varieties.

The farmer decides to give the improved grain a trial and purchases a few bushels for seed. He sows the new grain on the best part of

his field and prepares the ground unusually well. He is well pleased with the yield and becomes enthusiastic over the new variety. The next year perhaps the new grain does not have so good treatment and consequently does not yield so well. From this time the new variety of grain is given the same care and attention that he gave the less improved varieties which he has raised for many years. When decidedly unfavorable seasons occur the yield of the new grain falls below that of the more hardy and less improved varieties.

This farmer's standard of culture, fertility, and farm management is not as high as that which was required to produce the improved variety, consequently retrogression sets in at once. It is not very marked the first few years but with each succeeding year it becomes more pronounced until the time arrives when it is no better than those varieties which he formerly raised, in fact he sometimes actually approaches somewhat nearer complete failure than he did when cultivating the hardier, less improved varieties. In order that this improved variety of grain may thrive under the care and conditions which he provides for it, it must be able to withstand unfavorable conditions which were not required of it during the years when the variety was being improved, consequently hardihood is of considerable importance and it is developed under his somewhat careless management at the expense of useful qualities. Hardihood and proflicacy are not developed to the greatest extent in the same individual at the same time. Whenever one is developed to an unusual degree the other is correspondingly sacrificed. If the improved variety of grain must be made to withstand severe conditions it cannot maintain the highest standard of other useful qualities. In other words, the improvement is in part lost through the unfavorable conditions to which the variety in question is subjected. This simple description of a common-place affair may be taken as an illustration of the loss of many improvements which have been gained at the expense of life-long efforts of the foremost agriculturists. The improved varieties are undoubtedly able to withstand unfavorable conditions for a time, but if the conditions are more unfavorable than those through which the variety passed in being improved, the improvement will not be maintained, particularly when the variety falls into the hands of unskilled persons. Improved varieties are not so hardy as the less improved ones.

Man has endeavored, and has succeeded to a remarkable degree, in relieving both plants and animals of the struggle for existence in order that they might devote their energies toward producing desirable staples of food or commerce. Both animals and plants in the state of nature find the struggle for existence so great that hardihood is one of the chief features in perpetuating the species, As long as the energies of the organization are required to withstand

severe hardships through which the individuals must pass, the development of the qualities which would be most useful to man is quite out of the question. It is only when man by his skill and foresight is enabled to relieve the struggle for existence, that improvement takes place. As the plant or animal finds congenial surroundings as to food, climate, moisture, etc., it is able to develop, in the hands of the skilled breeders, characteristics which do not affect the vigor of the individual, and which may be turned by man to his own advantage.

The farmer who devotes considerable of his time to raising stock, like the grain farmer, endeavors to improve the quantity and quality of the stock which he is striving to produce at the least expense. He hears, that for certain purposes, improved breeds are superior to the common stock which has been kept for a long time in his neighborhood. He not only hears of these improved breeds and of their wonderful production, but he sees for himself individuals that are far superior to the best of those which he has been able to produce. He finally resolves to invest in pure bred stock with a hope that he may be able to produce more, and of a better quality, without increasing materially the cost of production. He invests in pure bred stock, takes the stock to his farm, and gives the so called "registered stock" the same care and treatment that the common stock of the country has received on his farm for generations. The improved stock does better for a few years. The individuals of the next generation, however, resemble their parents very much as to color and general appearance, although they are not quite so good. Each subsequent generation, while still bearing the color markings and many of the characteristics of the parents, proves to be less desirable than the generation that preceded it. Eventually the pure bred stock comes to the same level, as to production, as the stock which the farmer had maintained for years before. The farmer finally becomes convinced that the so called "registered stock" is no better than that which he formerly kept. Although it is descended, without a mixture of foreign blood, from improved parents, may be registered and is known as pure bred stock. Through the lack of sufficient knowledge the farmer has failed to maintain the improvement and to make the best use of his opportunities. If the improved breeds are really better than those that are unimproved they are better for practical purposes and will bring the largest returns when maintained under favorable conditions. Improved animals, like improved plants, cannot maintain their improved characteristics and be required to endure severe struggles for existence. Improved animals when properly cared for are able to turn to good account a larger amount of food, above that which is required for maintenance, than are those whose

energies are required to carry them through the many adverse conditions, some of which may occur at critical periods of life.

A farmer who has maintained a flock of fowls for years under very ordinary conditions may desire to secure a greater number of eggs than his fowls produce. He feels that he is not securing so large returns as are some of his acquaintenances who perhaps are taking better care of their stock and consequently maintain a higher standard. It is but natural that this farmer should try to imitate those who are doing better than himself. He perhaps recognizes that they have better machines to work with and are therefore able to produce more economically. He decides to obtain a better breed or variety of fowls than those which he has maintained for so long, and perhaps purchases from a skillful breeder some fowls of a breed or variety that is noted as being among the foremost of egg producers. The fowls which he obtains are used as foundation stock for his future flocks. They are more economical egg producing machines when properly maintained than were those which he maintained for years under somewhat adverse conditions. These new fowls bring an increased egg production for a time, even under the conditions to which he subjects them, consequently he is pleased with them and thinks that a marked improvement has been made by the change. The fowls of the next generation have most of the characteristics of their parents; they are perhaps a little smaller and do not lay so many eggs, particularly during the winter months. Each succeeding year finds him with a flock that is less satisfactory than the one of the previous year, until a flock is secured that is no better than the fowls which he kept before the improved breed was tried. In other words the change brought him improvement for a time but the improved stock deteriorated to the level of the unimproved which was as high a grade as the conditions which he provided would maintain. Those who do not provide improved food and care for the improved varieties of domestic animals cannot maintain the improvement which has been secured by skillful men at the expense of years of painstaking labor. Improvement in the so called useful qualities cannot take place to any great extent without corresponding improvement in food, care, and environment. Without exception all those who have become noted as improvers of plants or animals have maintained them under the most congenial conditions. All noted improvers of domestic animals have been skillful feeders. Careless and indifferent feeders have not improved a breed or variety.

The breeders and promoters of the so-called improved breeds and varieties of animals and plants have sought to impress upon their patrons the superiority and advantages of the improved qualities and have largely failed to impress upon the purchasers, both actual and prospective, the necessity of maintaining as favorable conditions

as were found necessary in effecting the improvement. As a consequence of the lack of this information a large proportion of the investors have become dissatisfied and convinced that the so-called improved breeds and registered stock are but little better, if any, than much of the more common stock of the country. As a burned child has learned to avoid the fire, so those who have tried and failed have lost confidence in the better things that are available if they but knew how to make the most of the advantages before them. One of the great hindrances in the advancement of agriculture is the lack of knowledge on the part of the practical men to make good use of the material at their command.

Those who try new methods and fail are oftentimes sufficiently discouraged to prevent them from departing from the practices which have come down to them unchanged through many generations. Instead of permitting improvements to be lost the practical agriculturist should be able to still further improve for the particular purposes for which they are maintaining plants or animals as the case may be. Nearly every breed and variety is susceptible of further improvement even under the conditions under which the improvement was effected. Much more readily may they be improved for the use of the individual who finds it necessary to maintain them under quite new and changed conditions.

Stock owners do not always realize that the improved breeds may be further improved for their use. As most of the improvements have been made under somewhat unusual conditions it becomes necessary for each breeder to still further change and adopt the breed in question to the best condition of life that he is able to provide.

Whenever the stock breeders, the fruit growers, and grain farmers realize that improvement cannot be maintained under ordinary conditions a united effort will undoubtedly follow which will give to agricultural advancement a greater impulse that has ever been recorded in the past. When we are able to look honestly at the questions which confront us and see the difficulties and obstacles as they really exist, then, and only then, will the fundamentals be understood sufficiently well to enable the highest possibilities to be realized. Let us make the mistakes and retrogressions of the past stepping stones to more certain and continual advancement of the agricultural interests which lie at the foundation of the future prosperity of this great country.

REPORTS OF

SPECIAL

EXAMINATIONS AND INVESTIGATIONS.

REPORTS OF SPECIAL EXAMINATIONS AND INVESTIGATIONS.

METHODS OF STEER-FEEDING.

CO-OPERATIVE EXPERIMENT BY THE PENNSYLVANIA DEPARTMENT OF AGRICULTURE AND THE PENNSYLVANIA AGRICULTURAL EXPERIMENT STATION.

UNDER THE IMMEDIATE SUPERVISION OF G. C. WATSON AND A. K. RISSER.

An article published in the Annual Report of 1901, page 495 (Bulletin No. 67), gives an acount of an experiment which was designed to test various methods of feeding steers. This experiment has been repeated in all essentials and the results described in the following pages. It is recognized that one trial, with a comparatively small number of animals, is not sufficient to determine the many questions involved in such a test. Therefore, the experiment herein described was designed to be largely a repetition of the one made the year previous, in order that the results of the two may be compared and that somewhat more reliable data may be secured for the information of those who are particularly interested in converting the roughage of the farm and commercial stock foods into the more valuable product of prime beef. The narrow margin of profit in feeding steers, which have been reared in other localities, compels the feeders to study closely the strictest economy as to the outlay of labor and money, and to note tendencies even before results are obtained. One object of the trial was to determine as far as possible the comparative cost as well as the efficiency of various methods of feeding.

Plan of the Experiment.

The experiment was devised to test certain practical methods of confining fattening steers as well as to test the usefulness of automatic watering devices for fattening animals as steers are usually confined throughout Pennsylvania. The experiment was designed to determine, if possible:

(1) The effect of different methods of supplying drinking water;
(2) The effect of different methods of confining fattening animals;

(3) The amount of labor required to care for animals under these various conditions.

Experiment No. 2. (Dec. 5, 1900, March 19, 1901.)

In order to make this test as satisfactory as possible under practical conditions, space was set aside in the basement of the college barn in a similar manner to that described in the report of 1901 (Bulletin No. 67). Three lots of steers were used in this experiment. One lot, Lot No. 1, consisting of ten animals, was placed in a large box stall 20x21½ feet in area, which is exactly the same space that the ten steers would have occupied had they been placed in stalls; that is, the stalls were removed and the space occupied by the stalls enclosed by high board partitions, which made, to all intents and purposes, a large box stall. On account of the lack of space, Lots Nos. 2 and 3 consisted of but six steers each. These were kept in stalls adjoining the box stall. Lot No. 1 (in the box stall) was supplied with water furnished by means of automatic watering basins, in which water was kept before the animals all of the time except when the water was withheld for a short time previous to the weighing periods. Lot No. 2, which consisted of six animals, was supplied with water by means of automatic watering basins similar to Lot No. 1. Lot No. 3 consisted of six animals, and was placed in stalls in a similar manner to Lot No. 2, with the exception that the steers were turned out once each day for an hour or two in a large yard adjoining the basement, where they were permitted to drink in common from a large watering trough. The animals of Lots Nos. 1 and 2 were not removed from the pen and stalls except as it was desired to weigh them on alternate weeks.

The Animals.

The steers used in this experiment were purchased at the stock yards in Pittsburg, November 21, 1900, by Mr. William C. Patterson, the Farm Superintendent, and the writer. In this connection, it should be stated that Mr. Patterson has successfully fattened one or more carloads of steers on the college farm each year for many years, and is recognized as an expert buyer. The steers selected were dehorned grade Shorthorn steers raised in eastern Ohio, and were carefully selected as to size, age and quality, so far as outward appearance would indicate. The steers were sorted into lots soon after they were purchased and were confined in the pens and stalls until the experiment was begun. The steers were sorted with great care in order that the lots might be as uniform as possible and at the same time have nearly the same average weight. These steers were tame and considerably above the average as to quality and general

appearance. They had been given considerable grain and were "well started." In fact, some butchers would have selected a few for slaughter. In the following table is given the weights of each steer at the beginning and close of the experiment, as well as at each weighing period on alternate weeks during the period of feeding.

Rations Fed.

Each lot was fed a grain ration consisting of nine parts of corn meal and one part of wheat bran by weight, in such quantities as would be readily consumed. The judgment of an experienced feeder was relied upon to determine the amount that should be given from day to day. An accurate account was kept of the total amount of grain consumed by each lot, but no effort was made to determine the amount of food consumed each day. The grain for each lot was weighed out weekly and placed in a bin. The feeder having access to this bin fed each lot the necessary amount. At the end of the week, that remaining in the bin was weighed and deducted from the amount previously weighed out. In a similar manner an account was kept of the hay and corn stover consumed by each lot of steers. The hay consumed by the three lots was of good and uniform quality, largely timothy with a little clover. The corn stover was well cured and shredded. The hay and corn stover were placed in large sacks and weighed and taken from the sacks and placed in the mangers as required. The unconsumed portions were weighed back and deducted from the total amount offered them, the difference giving the amount consumed. As the refuse was frequently small, it was not weighed back until a considerable amount had accumulated; that is, the unconsumed hay and stover were removed each day and kept until a considerable amount had accumulated, when the whole was weighed and sampled. The following table gives the amount of food consumed weekly by each lot:

Food Consumed.

Date.	Lot I.			Lot II.			Lot III.		
	Hay.	Fodder.	Grain.	Hay.	Fodder.	Grain.	Hay.	Fodder.	Grain.
For Week Ending:									
December 13, 1900,	525	274.5	1,031.0	309.5	112.5	532.5	299.0	89	531.5
December 20, 1900,	509	238.0	1,008.0	302.0	75	539.5	283.0	37	557.5
December 27, 1900,	529	235.0	989.5	293.5	97	638.5	265.5	62	484.5
January 3, 1901,	525	210.0	970.0	288.0	78.5	633.5	289.0	54	600.5
January 10, 1901,	518.5	209.5	1,026.0	293.0	81	666.0	264.5	46	584.5
January 17, 1901,	525	177.0	1,090.0	288.0	62	729.0	255	34	575.5
January 24, 1901,	525	207.0	1,137.0	276.5	63	769.0	265.5	55	660.5
January 31, 1901,	525	199.5	1,219.0	304.5	64	780.5	272	21	753.5
February 7, 1901,	525	190.0	1,253.5	291.5	60.5	820.0	262	40	808.0
February 14, 1901,	525	206.0	1,369.5	301.5	63.5	836.0	292	36.5	779.0
February 21, 1901,	525	182.0	1,330.5	297.5	97	746.0	287	66	675.0
February 28, 1901,	525	214.0	1,449.5	300.0	113.5	783.5	282.5	93	774.0
March 27, 1901,	525	197.5	1,438.0	299.0	103.5	780.5	281	120	685.0
March 14, 1901,	519	216	1,338.5	290.0	119.5	758.0	272	96.5	780.0
March 20, 1901,	440	176	1,265.0	235.0	196.0	637.0	228	86.5	648.0
Total,	7,761.5	3,132.0	17,915.0	3,369.5	1,286.5	10,649.5	4,098.0	936.5	9,896.5
Average per head,	776.15	313.20	1,791.50	728.25	214.4	1,771.7	683.0	165.68	1,649.4

It was observed early in the experiment that Lot No. 3 was not consuming so much corn stover per thousand pounds of live weight of animal as either of the other two lots, yet it did not seem advisable at that time to change the amount given them. Thus it was noticed that the steers that were turned out to water once a day corresponded quite closely in the consumption of corn stover to a similar lot of the previous experiment. The amount of hay and stover offered each lot and the amount refused are shown below, as well as a similar statement of the previous experiment.

Amounts of Hay and Stover Consumed by Each Animal of each Lot.

	Hay offered.	Hay refused.	Hay consumed.	Stover offered.	Stover refused.	Stover consumed.
Experiment No. 1, 1899-1900:						
Lot I,	1,107	11	1,096	503	189	314
	1,091	26	1,065	503	215	288
	1,068	52	1,016	501	321	180
Experiment No. 2, 1900-1901:						
Lot I,	780	4	776	338	75	313
	780	51.5	728.5	393	178	215
	780	97	683	393	236.5	156.5

The animals that were turned out in the year to water each day did not consume roughage as readily as those that were supplied with water from automatic watering basins.

It will be noticed that Lots Nos. 1 and 2 refused less hay and stover than Lot No. 3; also, that in both experiments Lot No. 1 refused the least hay and stover, that Lot No. 2 refused more and Lot No. 3 refused the most in both instances. In all cases the hay and stover that were not consumed were removed from the mangers and weighed. Practically none was thrown from the mangers and wasted by the steers. It is true that in 1899 and 1900, the three lots were not given quite the same amounts of hay and stover, although the difference in the amounts given was not great, and it should be noticed that the lots that consumed the least were given the least.

Weights and Gains.

In the case of nearly every animal, the increase in weight throughout the experiment showed considerable variation, as seen in the table of weights. This is no doubt due chiefly to the amount of water retained in the system at the time of weighing. In each case, the weight was taken at nine o'clock A. M., and after the water had

Weight of the Steers at Each Weighing.

Number.	Weight at beginning.	Second week.	Fourth week.	Sixth week.	Eighth week.	Tenth week.	Twelfth week.	Fourteenth week.	Final weight.
Lot I.									
63,	959	980.0	1,005.0	1,013.0	1,047.0	1,171.0	1,094.0	1,110.0	1,122.5
64,	1,013	1,052.5	1,080.0	1,127.0	1,173.0	1,211.0	1,200.0	1,232.5	1,242.5
65,	1,005	1,032.0	1,075.0	1,090.0	1,135.0	1,175.0	1,210.0	1,240.0	1,249.0
66,	1,015	1,032.0	967.5	1,098.0	1,117.5	1,160.0	1,191.0	1,202.5	1,216.0
67,	1,023	1,058.0	1,095.0	1,139.0	1,182.5	1,245.0	1,315.0	1,316.0	1,342.0
68,	972	1,035.0	1,044.0	958.0	1,095.0	1,138.0	1,150.0	1,172.5	1,193.0
69,	911	926.0	931.0	960.0	995.0	1,028.0	1,049.0	1,057.5	1,065.0
70,	911	945.0	972.5	980.0	1,060.0	1,010.0	1,041.0	1,070.0	1,069.5
71,	884	941.0	960.0	996.0	1,055.5	1,052.0	1,091.0	1,132.0	1,128.0
72,	788	815.0	840.0	869.0	891.0	919.0	950.0	980.0	990.0
Average,	948.0	982.0	997.0	1,023.0	1,069.0	1,111.0	1,129.0	1,151.5	1,162.0
Lot II.									
51,	882	912.5	951.5	980.0	1,025.0	1,059.5	1,083.5	1,100.0	1,127.0
52,	1,015	1,05.00	1,069.5	1,069.5	1,140.0	1,172.5	1,177.5	1,179.5	1,182.5
53,	963	1,007.5	1,019.5	1,055.5	1,087.5	1,116.5	1,140.0	1,172.5	1,184.5
54,	862	892.5	937.5	992.5	1,008.5	1,062.5	1,095.0	1,120.0	1,128.0
55,	976	1,007.5	940.5	1,062.0	1,102.5	1,155.0	1,187.5	1,217.5	1,238.0
56,	992	1,017.5	940.0	1,095.5	1,134.5	1,152.5	1,167.5	1,190.0	1,191.5
Average,	948.5	981.0	976.5	1,017.0	1,083.0	1,120.0	1,143.5	1,163.0	1,175.0
Lot III.									
57,	1,065.5	1,087.5	1,105.0	1,135.0	1,167.5	1,198.0	1,213.5	1,250.0	1,257.5
58,	1,064.5	1,117.5	1,170.0	1,155.0	1,180.0	1,213.0	1,218.5	1,237.5	1,244.0
59,	872.0	918.0	957.5	1,012.0	1,037.5	1,045.5	1,097.0	1,105.5	1,110.5
60,	888.5	917.5	965.5	975.0	1,010.0	1,037.5	1,067.5	1,092.5	1,096.5
61,	889.0	927.5	918.5	957.5	1,026.5	1,052.5	1,085.0	1,110.0	1,087.0
62,	923.5	947.5	975.0	962.5	1,030.0	1,053.5	1,078.5	1,085.0	1,087.5
Average,	950.5	986.0	1,012.0	1,033.0	1,075.0	1,100.0	1,126.5	1,146.5	1,147.0

been withheld for about sixteen hours. The weights at the beginning and end of the experiment were obtained by weighing each individual animal on three consecutive days and taking the average of these weights. It is well known that a single weight may be quite misleading as regards the true weight of the animal. As shown in the table of weights, some individuals at some weighings apparently lost weight. This is undoubtedly due to the variation of the water in the system of the animal at the time of weighing and not to any unthrifty condition at that time, as some of these animals have made most excellent gains throughout the whole period of feeding, which would not have been expected had they actually lost in weight during two or four weeks of the feeding, as indicated by the table of weights. Animal No. 68 of Lot No. 1, at the third and fourth weighing, indicated a loss of 77 pounds for four weeks, while this animal gained throughout the whole period an average of 2.13 pounds per day. Without doubt, the weights were misleading and the animal did not show an unprofitable feeding condition. The following table gives the gain of each individual of each lot:

Steer No.	First weighing.	Last weighing.	Total gain, pounds.	Gain, per cent.	Gain per day, pounds.
63,	959	1,122.5	163.5	17.05	1.57
64,	1,013	1,242.5	229.5	22.06	2.21
65,	1,005	1,249	244	24.28	2.35
66,	1,015	1,216	201	19.91	1.93
67,	1,023	1,342	319	31.18	3.07
68,	972	1,193	221	22.74	2.13
69,	911	1,065	154	16.90	1.48
70,	911	1,069.5	158.5	17.40	1.52
71,	884	1,128	244	27.60	2.35
72,	788	990	202	25.63	1.94
Total,	9,481	11,617.5	2,136.5		20.54
Average,					2.05
51,	882	1,127	245	27.78	2.36
52,	1,015	1,182.5	167.5	16.50	1.62
53,	963	1,184.5	221.5	23.00	2.13
54,	862	1,128	266	30.86	2.56
55,	976	1,238	262	26.86	2.52
56,	992	1,191.5	199.5	20.12	1.92
Total,	5,690	7,051.5	1,361.5		13.09
Average,					2.18
57,	1,065.5	1,257.5	192	18.02	1.85
58,	1,064.5	1,244	179.5	16.81	1.72
59,	872	1,110.5	238.5	27.35	2.29
60,	888.5	1,096.5	208	23.41	2.00
61,	889	1,087	198	22.28	1.90
62,	923.5	1,087.5	164	17.76	1.57
Total,	5,703	6,883	1,180		11.34
Average,					1.89

From the above table it will readily be seen that Lot No. 2 made the greatest average gain per day; also, that Lot No. 1 occupies a medium position between Lots Nos. 2 and 3. There is not difference enough in the gains of the three lots to warrant the claim of marked superiority of one method over another, as the three lots gave about as uniform results as would be expected from three lots kept under uniform conditions. The objection to feeding a number of steers in a yard or pen has been raised, that there is likely to be both underlings and those that make unusually good gains. It is true that steer No. 67, of Lot No. 1, made considerably greater gain than any in Lots Nos. 2 or 3, and also that one steer, No. 69, made the least gain of any of the three lots, although No. 62, of Lot No. 3, which was confined in a stall, did not greatly exceed the small gain of steer No. 69. While the gains of the steers of Lot No. 1 occupy both extremes, yet they are sufficiently pronounced to warrant any definite conclusions being drawn from these results. The following table gives the amount of food consumed by each lot per pound of gain of live weight:

Food Consumed per Pound of Gain in Live Weight.

	Hay.	Stover.	Grain.
Lot I,	3.62	1.46	8.39
Lot II,	3.21	.94	7.82
Lot III,	3.47	.79	8.39

Amount of Food Consumed.

	Hay.		Stover.		Grain.	
	Total.	Per 1,000 pounds, live weight.	Total.	Per 1,000 pounds, live weight.	Total.	Per 1,000 pounds, live weight.
Lot I,	7,761.5	735.7	3,132.0	296	17,915	1,698
Lot II,	4,369.5	684.5	1,286.5	202	10,649.5	1,671
Lot III,	4,098.0	651.2	936.5	148.8	9,896.5	1,572

From the above it is seen that Lot No. 2 made a pound of gain in live weight with the least amount of food. This lot also made the greatest gain per day throughout the whole time of feeding. While Lot No. 1 made a somewhat greater gain than Lot No. 3, it evidently was at a somewhat greater expense of food, as Lot No.

3 required a trifle less food to produce a pound of gain than Lot No. 1. It is also shown that Lot No. 3 consumed less food per thousand pounds of live weight than either of the other two lots.

The differences in the results of these two methods of feeding, as shown by these trials, are not sufficient to warrant definite conclusions.

Experiment No. 3.

On April 1, 1901, six steers were placed on experiment similar to the one previously described. The main object of this experiment, however, was to determine whether there was a great difference in the retention and preservation of the manure made from the three lots. The steers were weighed at the beginning and end of the experiment, as described in experiment No. 1, and the food was weighed and fed as described in that experiment. Each lot consisted of two steers. The steers of Lot No. 1 were loose in a box stall and supplied with water by means of an automatic watering basin. The steers of Lot No. 2 were confined in stalls, but supplied with water by automatic watering basins, and Lot No. 3 was watered as were the animals of Lot No. 3 of experiment No. 2. The following table gives the weights of the steers at the beginning and end of the experiment, gain per cent. and gain per day in pounds:

	First weighing.	Last weighing.	Total gain, pounds.	Gain, per cent.	Gain per day, pounds.
Lot I.					
Steer No. 1,	912	1,081	169	18.53	2.96
Steer No. 2,	876	1,016	140	15.98	2.46
Average,	894	1,048.5	154.5	....	2.71
Lot II.					
Steer No. 3,	926	1,075	149	16.09	2.61
Steer No. 4,	862	1,046	184	21.35	3.23
Average,	894	1,060.5	166.5	....	2.92
Lot III.					
Steer No. 5,	976	1,131	155	15.88	3.04
Steer No. 6,	784	905	121	15.43	2.37
Average,	880	1,018	138	....	2.70

It will be observed that Lot No. 2 made a slightly greater gain than either of the other lots. Lots Nos. 1 and 3 were practically the same. The following table gives the food consumed for each lot. It should be noted that the coarse fodder fed these three lots consisted entirely of hay. While the gain of these steers in live weight corresponds quite closely to that of experiment No. 1, yet it is shown below that Lot No. 3 consumed considerably less food per pound of gain of live weight than either of the other two lots:

Food Consumed.

Date. For Week Ending:	Lot I.		Lot II.		Lot III.	
	Hay.	Grain.	Hay.	Grain.	Hay.	Grain.
April 9,	168	183	141	200	91	166
April 16,	164	228	144	206	87.5	148
April 23,	164	237	138	191	82	141
May 7,	177.5	235	155.5	223.5	124.5	216
May 14,	176	234.5	160.5	223	129	234.5
May 21,	163	234	175	220	155	231
May 29,	192	268	173.5	264	*33	*60
Total,	1,371.5	1,825.6	1,252.0	1,746.5	840.5	1,365.5

*For two days only, Lot III was sold May 23.

Food Consumed per Pound of Gain in Live Weight.

	Hay.	Grain.
Lot I,	4.44	5.91
Lot II,	3,76	5.24
Lot III,	3.45	4.95

Labor Required.

The labor of attendance is often a deciding factor in the selection of stock for fattening, and it also determines the manner in which the stock should be fed. The cost of the manual labor required to take proper care of the stock in question sometimes determines the profit. Systems of feeding that require the least labor are to be preferred, provided, they are equal as to the amount of food required and the gain secured. The following table shows the amount of labor required for attendance for each lot during the entire feeding experiment of 104 days:

Time of One Man Required for Attendance.

	Number of animals.	Actual number of hours.	Hours.	Percentage of Lot 3.
Lot I,	10	79.6	79.6	51
Lot II,	6	88.8	†148.0	†95
Lot III,	6	93.3	†155.5	....

†Calculated to ten animals, the number in Lot I.

As shown above, it required 79.6 hours of actual labor of one man to attend to ten animals of Lot No. 1, and 93.3 hours of labor to care for six animals of Lot No. 3 that were kept in stalls and turned out to water once each day. If this proportion is used to determine the amount of labor required to care for ten animals in stalls, it will be seen, as shown in the above table, that steers in pens furnished with automatic watering basins required about one-half as much time of the attendant to properly care for them as was required to attend to the same number of animals kept in stalls and turned out in a yard to water. The stalls were cleaned out each day and the box stall was cleaned out twice during the experiment. The following table is taken from Bulletin No. 67, which gives the difference in time required to care for the three lots of animals which were kept under similar conditions as those described in the preceding pages:

Time of One Man Required for Attendance.

	Hours.	Percentage of Lot III.
Lot I.	93.66	76.0
Lot II.	113.33	92.0
Lot III.	123.25	....

In this experiment each lot consisted of five animals, which undoubtedly made the lots too small to note the greatest difference in the time of attendance.

Bedding Required.

It has been maintained that there is a saving in bedding when the animals are kept in large pens or yards. The question of saving bedding is oftentimes of considerable importance. In some localities, where large quantities of straw are available, it is desired to make use of the largest amount that can be used profitably. On the other hand, where there is a scarcity of bedding material, it is oftentimes desirable to care for the animals in such a manner that the least amount of bedding will be required. Throughout this feeding experiment a strict account was kept of the weight of the bedding material. Straw was used exclusively. This was weighed out in large sacks and a record kept of the number of sacks used for each pen. At the close of the experiment, it was found that the same number of pounds was used per animal in each lot. The use of straw was left to the judgment of the feeder. He determined how much was necessary to keep the animal clean and comfortable.

From the foregoing pages it will readily be seen that the differences in the results of the three methods of confining fattening steers, do not show that one method is markedly superior to another, so far as gain in live weight from the food consumed is concerned. The results of the three methods, as shown by each experiment, are about as uniform as would be expected had the three lots of them been kept under practically uniform conditions. The slight differences in gain are not sufficient to recommend one method over another. While the steers were selected with great care, yet the differences in the individuals of the three lots may account for the slight difference in gain. The fact that a different lot in each experiment made the greatest gain from a given amount of food, tends to show that the variation of the lots is probably due to the individuality of the animals rather than to the difference in the methods of confining and feeding.

It was observed in each experiment that those animals which had a supply of water before them all the time had a somewhat better appetite and consumed their food with greater relish than did those that were turned into the yard to water once each day. Any advantage that one method may show over another is chiefly due to the difference in the amount of labor of attendance.

TREATMENT FOR SAN JOSÉ SCALE IN ORCHARD AND NURSERY.

BY JOHN B. SMITH, Sc. D., *Entomologist of the New Jersey Experiment Station.*

The San José or Pernicious Scale seems, from present evidence, to be a native of Asia, occurring in Japan and China under such circumstances as to make it improbable that it could have been introduced from any other country. It is only within the last year that the matter has been fairly settled by the researches of Mr. C. L. Marlatt of the U. S. Department of Agriculture, and not the least important of his observations is that, where the insect occurs naturally, it is not injurious; that is, the insect and its host plants are so balanced that both exist without inconveniencing each other.

Mr. Marlatt's studies point to a species of lady-bird, closely allied to our own twice-stabbed species, as the check that prevents undue increase, and the natural suggestion is, that this predatory species be introduced into the United States to do for us what it does in Asia—i. e., control the pernicious scale. Attempts in that direction are under way and will be again referred to.

Just when the insect was introduced into the United States, no one knows definitely. It is probable that it was in 1870 or before. It is certain that in 1873 it was fully established in the Santa Clara valley, in the vicinity of San José from which the insect derives its common name.

HISTORY IN CALIFORNIA.

Not until 1880 did the insect come before the Entomologist for study. In that year Prof. J. H. Comstock, then Entomologist to the U. S. Department of Agriculture, determined that it was undescribed and called it *perniciosus;* basing his name upon the destruction which

it at that time caused in California orchards. He considered it the most pernicious scale known to him and found it on all deciduous fruits except black Tartarian cherry.

It spread rapidly throughout the fruit regions of the Pacific coast and caused serious injury on every hand. It was fought with all the usual insecticides with more or less success and, in the experiments made, the lime, salt and sulphur wash was developed. This proved peculiarly adapted to California conditions, and turned out uniformly satisfactory results when the proper methods of preparation and application were fully understood.

Meanwhile the citrus orchards became infested by another scale insect, introduced from Australia or some one of the neighboring countries, and this proved so much more destructive that, for a time, the pernicious scale was deemed scarcely worthy of consideration. The new scale was much larger, with a prominent white egg case in the female, and was called the Cottony Cushion Scale. Though at first attacking citrus trees, it soon invaded deciduous orchards as well, and, resisting all the known insecticides, brought the fruit growers face to face with failure.

Relief came with the discovery of the natural check to this insect and its introduction into California. In a marvelously short time the Cottony Cushion Scale was under control, and then it was realized that in many sections of South California the San José Scale was no longer a destructive pest. It was practically kept in check by natural enemies, and these were said to be certain species of Australian lady-birds belonging to the genus, *Rhizobius*, which had been introduced with *Vedalia*, to fight the Cottony Cushion Scale. This was the condition of affairs when, in 1896, I visited the Pacific coast to secure, if possible, such information as might guide the New Jersey horticulturists in their fight against the pernicious scale in that State.

TREATMENT AND NATURAL CHECKS IN CALIFORNIA.

In Southern California the insect is really under control, and the effective agents are, first, the twice-stabbed lady-bird, *Chilocorus bivulnerus;* second, a minute parasitic wasp, *Aphelinus fuscipennis*. There were some other species found feeding on the scales, but they were of no great importance in comparison with those already mentioned.

The interesting point is, that the twice-stabbed lady-bird is a close ally of the species that is doing such good work in Asia. So similar are the species, indeed, that to the untrained eye they would readily pass as the same. This twice-stabbed lady-bird occurs not uncommonly in the Eastern United States, and I have bred in New Jersey from the pernicious scales, the same little *Aphelinus* which is found in California. Practically then, we have in the East all the species that control this scale in Southern California. But as one travels North, it is found that the natural enemies are less effective, and the fight against the insect is still in progress. Resin washes and lime, salt and sulphur were everywhere in evidence; but, practically, the growers are all coming to accept the latter of these mixtures as the most satisfactory.

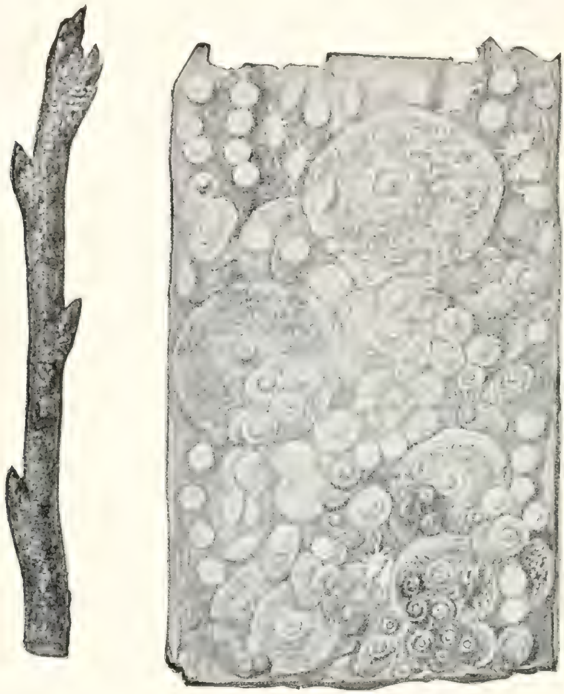
After twenty-five years, California has solved the San José Scale problem and, greatly assisted by nature, has the insect fully under control. The matter of the lime, salt and sulphur wash will be again referred to. The important fact to be recognized here is, that it was not until after a long, hard fight—after thousands of trees had been killed and after years of experimenting—that the insect was finally controlled. We will attain the same result in the East; but it may have to be done in a somewhat different manner.

ITS INTRODUCTION AND SPREAD IN THE EASTERN UNITED STATES.

In either 1886 or 1887, two New Jersey nurseries secured plum and pear trees from the Pacific Coast from which they propagated, by ordinary nursery methods. It was not known that these trees were infested by any unusual scale, and buds and cuttings were freely used in the nursery blocks. Both nurseries grew more or less fruit commercially, and the bearing trees soon became infested. From these, other nursery blocks were annually supplied and, in 1890 and thereafter, scaly trees were sent out in all directions. The two nurseries affected were the most extensive in New Jersey, and had a trade

throughout the Eastern and Central United States; therefore, a considerable section of the East was covered before the existence of the insect there was even suspected.

The first case was found in Virginia, in 1893, and in 1894 the facts concerning the distribution of the pest were ascertained and published.



a *b*

Fig. 1.—San José Scale; *a*, on twig, natural size; *b*, bark of same much enlarged, showing scales of different ages and also the crawling young. (*From Howard and Marlatt, Bull, 3, N. S., Div. Ent. U. S. Dept. Agr.*)

It is probable that one if not two nurseries in another State assisted in spreading the scale through other California stock, and it is certain that some scaly trees were received directly from Japan. But nurseries are chiefly responsible for spreading the insect over an area that natural methods of spread could not have covered in a dozen years. Even now, with all our guards and nursery control, this distribution continues to some extent.

LIFE HISTORY OF THE INSECT.

Before one can deal intelligently with any insect, it is necessary to know its life history and habits, that our efforts may be intelligently directed; therefore a brief description is here given.

The full grown scale, when by itself on a twig, is almost circular in shape and about one-sixteenth of an inch in diameter. It is blackish gray, the centre a little raised and dull yellow in color. It is not at all conspicuous, especially on gray bark, and is very easily overlooked. When grouped in large numbers the individual scales vary a little in shape; but are always small, round, dark gray discs with a yellow center. If, with the point of a knife we carefully lift one of these scales we find lying free, underneath it, a much smaller, flattened, bright yellow, soft bodied creature—the scale-insect itself. This has neither legs, wings or other organs of locomotion and, in fact, no appendages except three fine bristles which form the mouth. These bristles are inserted into the plant tissue and by this means the insect holds its place. In other words, there is a very small, bright yellow, grub-like creature, covered by a scale of its own manufacture.

A scale insect, such as described, is a female and, when mature, it gives birth to living young. The period of reproduction extends throughout a month or six weeks, and in that time an individual may give birth to about 500 young. These young, or larvae, are minute yellow atoms with short legs and feelers and are capable of motion. On a badly infested tree, when the insects are breeding, the surface will appear covered with moving pollen grains, so small are they. Their bright color makes them conspicuous, and with a little practice one may see them readily with the unaided eye. They move about quite actively for such small creatures and usually tend outwardly, to the smaller branches, fruit spurs, leaves, or to the fruit itself; in fact, except on peach, the fruit is a favorite place. After about twenty-four hours of this active life the larva finds a suitable place, inserts the microscopic mouth bristles into the plant tissue, begins to feed and is then a fixture. In a few hours it begins to contract and becomes circular in outline, like a minute, yellow lentil. Then little, white, cottony filaments come from specialized pores all over the surface until the creature looks like a tiny lump of cotton. These filaments or threads run together and form the first covering to the fixed larva. In this stage the white color makes them easy to see;

but they remain so for a few days only. Additional waxy material is added at the edges, the scale enlarges, becomes darker in color, more flattened, and reaches the gray stage. From this the color changes to black and later, as it becomes mature, it again lightens and the yellow centre becomes obvious. In about four weeks full growth is attained and the female is sexually mature. If we follow the insect beneath the scale, we find that as the covering increases, the antennae and legs disappear and, when the first larval skin is cast, no appendages remain. The cast skin is made to form part of the centre or nipple of the scale, and in the female, a second cast is added before the insect is sexually mature. The male at its next change differs totally from the female and forms a true pupa, from which we get in a few days, a very minute, frail, two-winged fly with long stout feelers, long legs and a long anal style or process. This male is so small and inconspicuous that it is almost impossible to see it without a magnifying glass, and so frail that the least puff of wind carries it off; nevertheless, it succeeds in impregnating the female and then dies.

Fig. 2.—Adult male, *Aspidiotus perniciosus:* greatly enlarged. (*From Howard, Circ. 3, 2d ser., Div. Ent., U. S. Dept. Agr.*)

Breeding begins in the latitude of Philadelphia about June 10, and continues throughout November in ordinary seasons. During that time a single pair may, if absolutely unchecked, produce a progeny of over one thousand million (1,000,000,000)! This number is so enormous as to be almost incredible; but from the facts given it may be easily figured out by any one with a mathematical turn of mind.

It has been stated that breeding continues until very late in the fall, but those insects that start late never live over until the fol-

lowing spring. And so the young that are born after frosty days and nights are fairly established, die before they reach a stage that enables them to live through the winter. A badly infested tree examined in mid-winter will show many white and gray scales—all dead; and plenty of fully developed females, some with young beneath their scales—also dead. The living individuals are those under the black scales, that may be considered half grown. These become completely dormant and do not resume growth until the following May. The males appear about the middle of that month, fully three weeks before the females begin to reproduce; but after reproduction once begins there is little cessation until the end of the season.

The important points in this history are, that the insect passes the winter well protected by a dense waxy scale, impenetrable to ordinary insecticides; that the newly born larvae are naked and unprotected, readily reached by any contact poison; and that after midsummer, reproduction is practically continuous.

PLANTS SUBJECT TO INFESTATION.

In a general way all the ordinary orchard trees in the Eastern United States are subject to infestation; but cherry suffers least—some varieties being totally exempt. Quince suffers little and has not been seriously damaged in any case that has come under my notice. Peach suffers most and there seem to be no exempt varieties. On peach the scale will ordinarily, if unchecked, kill trees the third year from the date of infestation. Plums are almost as susceptible, but individual varieties or even individual trees resist strongly, and may live for several years, completely incrusted by the insect. Apples are all good subjects, but the Ben Davis seems to be most susceptible and most difficult to clean. Pears differ widely and, where mixed with other trees, Keiffers are almost exempt. Most of the Asiatic varieties suffer little, and individual trees may be entirely exempt. Almost all the shrubby small fruits are subject to infestation; of these the currant is most injured, gooseberry the least. Blackberry and raspberry are somewhat infested, but not ordinarily much hurt.

Grapes are quite generally infested, but are not harmed. The slivery character of the bark on the old stock discourages setting by the larva and the new growth is almost always cut off nearly to the base; therefore the insects get little real opportunity.

Hedge plants are often badly infested. Japanese quince is one of the worst, and Osage orange comes very closely after.

In fact it may be said that there is scarcely a deciduous shrub or tree on which the insect may not maintain itself, though it may not cause actual injury. On shade and forest trees, it does not seem to cause much trouble. I have seen it abundantly on small European elms, and, to a lesser extent, on the American varieties; but never on older trees to a troublesome extent. So I have found it rarely on maple and poplar and very abundantly on willow. The latter is sometimes injured and I have seen the Kilmarnock variety killed by the scale.

Of the nut trees, hickory and walnut may be infested and the latter may be injured. Chestnut may become infested, but the insect does not thrive on it and the trees do not suffer.

Conifers are entirely exempt from attack so far as I have observed, and privet is practically so; hence we are not left entirely without hedge or ornamental plants.

Herbaceous plants, or such as kill down to the root during the winter, do not serve as host plants for the pernicious scales, because they cannot hibernate on it.

The insect is absolutely dependent upon the tissue upon which it is fixed, and if the latter dies, the insect dies also. If a scaly leaf drops to the ground, every scale dies as soon as the leaf is dry. The same is true of a twig or branch when cut from the tree; hence, if trimming is done during the winter in a scaly orchard, the cut wood may be safely left on the ground. The insects canot leave it, and long before the commencement of the breeding season all sap will be out; so, the insects having had nothing to feed upon, will be dead.

THE INJURY AND HOW IT IS CAUSED.

When a scale-insect first fixes itself upon a succulent twig or fruit and begins to pump out the plant juices, no immediate change is observable. But after a week or two a faint reddish tinge becomes evident around the scale and in the bast from which it feeds. As the insect grows, a depression is apt to be found on the bark where it is lodged and the red tint becomes more obvious. On the fruit it is often so marked, that an infested tree in bearing, is most readily detected by the prominent spots on the fruit. The discoloration is

supposed to be caused by the action of a saliva introduced into the plant tissue, and it undoubtedly causes something like a true poisoning. The injury caused by a single insect is as nothing to a tree; but when this is multiplied by many thousand it becomes a serious matter. The surface of the twigs becomes irregular and pitted; the bark dies, cracks and the upper layers become lifeless. The purplish red stain in the bast extends and gets even into the sap-wood. The tree loses vigor and in late summer some twigs may die at the tip. During the winter an entire branch may die. A start is usually

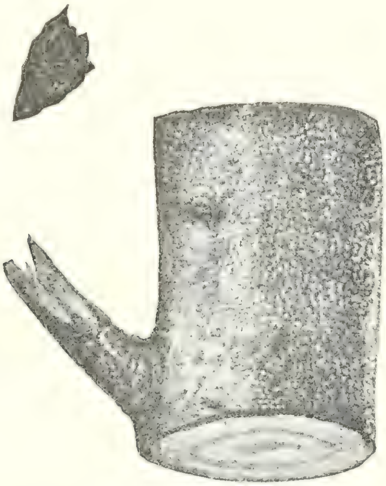


Fig. 3—Section of apple, natural size, closely set with scales; a bit of scaly bark enlarged, at left, above. (*From Howard, Circ. 3, 2d ser., Div. Ent., U. S. Dept. Agr.*)

made in the spring; but when the first drain is made by a dry spell upon the circulation of the tree, it fails to respond. The poisoned bast and sap-wood prove unable to meet the demand and the tree dies. Often a tree may go into the winter in apparent fair condition; but will break down suddenly in early summer. Peach trees are especially apt to do this, and many a dead tree has been charged to the insecticide employed when, as a matter of fact, it was already doomed when the application was made. It is important, therefore, to make whatever remedial applications are intended, before the tree or plant is so badly injured that it is unable to recover when the insects are killed.

NATURAL METHODS OF SPREAD.

It has been been already described how, through nursery stock, the pernicious scale was scattered throughout the Atlantic and Central States; but after all, this method would reach only individual orchards here and there and, on the whole, only a comparatively small number of trees would be infested. The question here to be answered is,—how, when a few trees in an orchard or a vicinity are affected, does the insect get to other trees or orchards.

The natural powers of locomotion of the scale insect are altogether inadequate to carry it from one tree to another unless the branches or twigs touch or interlace. I have seen in young apple orchards, individuals scaly for three years and no trace of spread to other trees; though those originally infested were killed. In truth, no scale larva will voluntarily leave the plant on which it is born. If it does, it has not the strength to enable it to get from one tree to another over a rough soil, even if it had the ability to move in a straight line to a determined end. In fact it has not such ability and the distribution is hap-hazard, by external agencies alone. When a badly infested tree is swarming with larvae, the little creatures get upon anything that is quiet long enough for them to do so. The foot of a bird, or an insect of any kind, may serve as a carrier. Sparrows, where they are at all abundant, are the usual agents. They sometimes congregate in flocks; crowd a tree; chatter volubly and then fly to another near by or a long distance off. With them they carry from one tree to another, from orchard to hedge and hedge to orchard, any scale larvae that may be at the time moving on any of the plants visited by them. Other birds do as much in another manner. A mother seeking food for her brood will visit a tree again and again, hunting caterpillars, and will carry them to her young. She spends much time about her nest, and near it the first trace of scale on old trees can nearly always be found.

The very lady-birds that feed on the scales serve as agents for their spread. The writer has seen the twice-stabbed lady-bird busily feeding on infested twigs, and half a dozen or more larvae crawling safely about on its wing covers. When the beetle flies, the larvae travel with it. So there are many other agencies that may carry the young from place to place. Even the wind may at times serve as a distributor. In one case the writer showed an orchardist how he, himself, was infesting previously clean trees. He had been cul-

tivating among infested small trees and had, by striking the lower branches, become pretty well covered with larvae; his straw hat being especially well supplied. He left this infested lot for an old apple orchard and there seated himself on the ground, with his back against the trunk of a tree, and his hat in a convenient crotch. From that hat, larvae by the dozen were getting upon the tree when I was led by some suspicion to examine it! Birds first, insects second, winds next and careless horticulturists last, may be enumerated as the natural methods by which this scale insect spreads from place to place.

NATURAL ENEMIES.

This subject has been touched upon incidentally, on a previous page. The most important of the predatory enemies, are two species of lady-birds and a minute, parasitic wasp. One of these is the twice-stabbed lady-bird, *Chilocorus bivulnerus*, which has done such

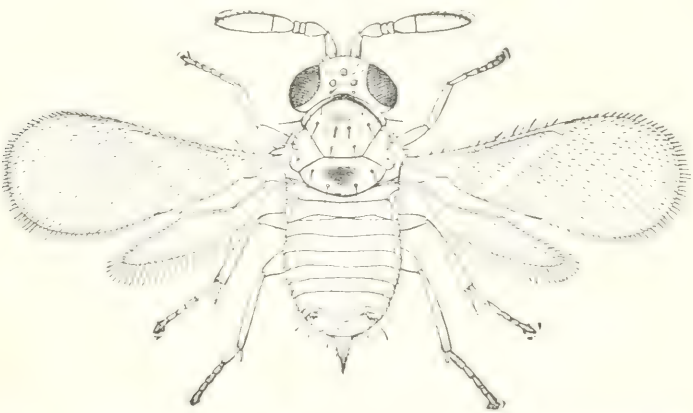


Fig. 4.—*Aphelinus fuscipennis*, very much enlarged. (*From Howard and Marlatt, Bull. 3, n. s., Div. Ent., U. S. Dept. Agr.*)

good work in Southern California. It fails to do equally well for us in the East, because our climate is such that it can make only two annual broods and these not very large; in Southern California it breeds nearly all the time and eats dormant scales by the hundred before they start breeding in spring.

The other of the lady-birds is the *Pentilia misella*, not much larger than the scale itself and black in color. This seems to breed all summer in considerable numbers and remains on the trees in cracks and crevices all winter; but it is so small and, compared with the scale, breeds so slowly, that practically the farmer gets little benefit.

The little wasp parasite is *Aphelinus fuscipennis*, which has been also mentioned as occurring in California. It is found in the East

wherever the scale occurs, and always takes a certain percentage of specimens. The female lays a single egg in a scale insect and the parasite larva develops and comes to maturity within the body of its host. Other lady-birds feed on the crawling larvae, and some other predatory species pick them up occasionally; but nothing is really effective as a check.

In 1896, the writer introduced into New Jersey a large number of lady-birds from California. All of them died. In 1898, he introduced the *Chilocorus similis* from Japan; but this also died.

Other natural checks, are heavy rains in the breeding season and diseases. The writer has seen hundreds of larvae washed down and battered to death by a heavy summer shower, and knows from observation that damp cold weather is fatal to many of the crawling stage.

Disease plays an important part in the multiplication of the species, and its percentage affects very materially the rate of increase. On some trees, in some years, the writer has found ninety per cent. of the scales dead from some unknown disease; but thus far this has been neither isolated, studied nor propagated. Prof. Rolfs found a transmissible disease in Florida, that was effective there, and he succeeded in getting pure cultures. Some of the diseased scales and some of the cultures were brought into New Jersey, and on a few scaly trees the disease was actually established; but it was found that the climatic conditions were not favorable for its spread, and while for two years the disease was active where it was established, it has not extended to other trees and did not even control the scales where it had taken hold.

Up to the present then, we cannot in the Atlantic States, depend upon natural checks for effective assistance in preventing injury from the San José or Pernicious Scale.

THE SCALE PROBLEM AS IT CONFRONTS THE HORTICULTURIST.

The presence of the pernicious scale in any orchard offers two alternatives to the fruit grower. He must either abandon his trees or he must fight the insect actively, persistently and intelligently. If he has an infested peach orchard the need for action is imperative or his trees will be beyond help. Other trees will last longer, but as soon as the insect extends throughout the tree, the fruit will be-

come unsaleable. He can expect no present help from nature; but I do not mean to say that changes in natural conditions will not in time make matters more easy. California suffered for a quarter of a century and still must fight in some localities. We have had the insect scarcely more than a decade; yet in New Jersey, horticulturists are holding their own against it.

If the fruit grower decides to fight, he must, if he expects success, realize that it will not be a short, sharp effort, but a long, steady task that is before him. He must become fully acquainted with all stages of the insect and its habits; not from reading this bulletin alone, but from personal verification of its statements, in the orchard. He must become acquainted with the peculiarities of his trees; what treatment they will stand, and what he must avoid. He must determine by actual experiments, based upon the information here given, just what he can do most effectively and most economically. No one application of any material can be completely successful, because it is a physical impossibility to hit every scale on a tree of any considerable size. There are always a few protected examples that escape our most thorough treatments and these will serve to restock the trees. A little carelessness may allow so many to escape that in a single season a tree may become as bad or worse than it was when the treatment was originally made. Finally, he must determine whether he will depend mainly upon summer or winter work, or whether he will combine the two.

In summer the presence of the foliage makes the use of the more powerful insecticides impossible; but on the other hand the insects are much more easily killed. In winter very caustic or very penetrating applications may be made; but the insects are dormant and better protected than at any other period of their existence.

SUMMER TREATMENTS AND THEIR RANGE.

Summer treatments may begin with the date when the scale first begins to reproduce—June 10—and need not end until reproduction ceases—about November 15. Before the former date the scales are not more easily penetrated than during the winter; after the latter date those that may be killed by summer mixtures would die even if no application was made.

Summer mixtures are such as may be applied to living foliage or actively growing shoots without causing injury. To be worth considering here, they must also kill the scale at the strength at which it is safe to use them on foliage.

The only insecticide which, so far as my experience goes, answers all these purposes, is whale (or fish) oil soap. I have used tobacco mixtures, other soap mixtures and kerosene, pure or emulsified; but on the whole, whale (or fish) oil soap is the best. At the rate of one pound in three gallons of water, it may be applied safely at any time after June 15, on any tree except peach and it will kill all larvae and recently set forms. Of course this leaves the old scales alive; but forms a check to increase that is very effective. Early breeding is in full swing about June 20, and an application thoroughly made

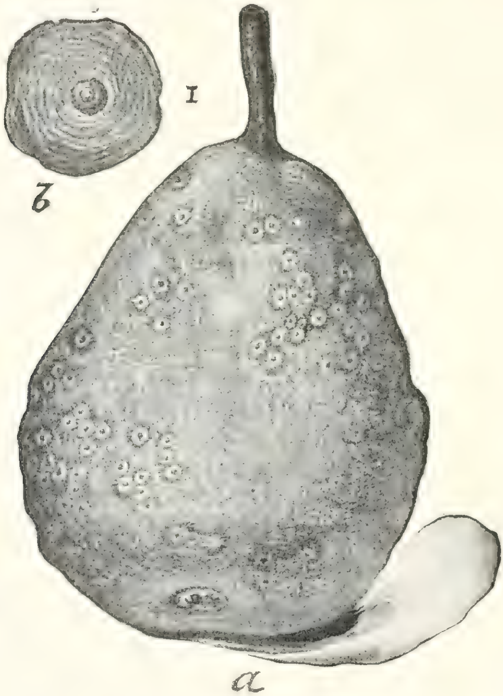


Fig. 3—A pear, natural size, infested by the San José Scale. The scales are shown as black dots, the surrounding shade representing the purplish discoloration; at *b*, a single scale is shown, very much enlarged. (*From Howard, Circ. 3, 2d ser., Div. Ent., U. S. Dept. Agr.*)

at that time, will wipe out so many of the young that unless it is very bad the tree will go safely through the summer. On peach, one pound in four gallons of water is the limit of safety in June. The heaviest broods of scales come in late September and early October, and at this time trees not bad during the early season may be swarming with young. Now even peach will stand one pound of soap in three gallons of water, and all other trees will stand one pound in two gallons. The foliage in early October is mature, the buds are form-

ing, and there is nothing that is readily injured except the scales. A thorough application then made will kill off the very forms that would otherwise live safely through the winter. A thorough application in late June and another in early October should keep the trees fairly safe without winter treatment. Ordinarily, however, the fruit grower prefers to make his radical applications in winter, and in that case his summer applications are intended mainly to prevent the tree from being severely injured before winter sets in. The soap mixture may be applied at any time when needed, and at least once every two weeks after the middle of June the owner of an infested orchard should go through it carefully enough to determine whether any trees need treatment.

Instead of soap, kerosene or crude petroleum may be used. These are much more effective but require much more care in their use.

A fruit grower at Middlebush, N. J., uses summer applications of crude oil in his plum orchard continuously and finds no difficulty in controlling the scale. He keeps his trees trimmed low and under constant supervision. When he notices considerable scale breeding on any tree, he applies the oil by means of a knap-sack sprayer through a fine Vermorel nozzle. The application is made to the trunk and larger branches only, and in general, in the centre of the tree; foliage being avoided so far as possible. As the oil kills the insects in all stages, the sprayed portion becomes and remains clean for the balance of the season. In this way, though the trees are always more or less infested, the insects are kept down to harmless numbers. It requires some experience before a man uses crude oil confidently; but when that experience has been gained, it is surprising how freely it may be used with safety. I have treated the trunks and branches of peach trees with equal success and equal safety; but I would advise caution and experimental applications on such trees before adopting the method on a large scale. The rule should be, just as fine a spray as possible and just enough to wet the treated surface. The trees should be dry when the application is made.

Kerosene of the grade used for illuminating may be used instead of the crude oil and is safer. It kills the insects almost as well, and is not so hard on the foliage; but it has no protective effect and, within twenty-four hours after an application has been made, scale larvae may set safely on the treated surface. Those who have learnt how to use kerosene prefer it to the crude oil, and it is certainly cleaner. The same rule as to the character of the spray and the dryness of the tree should be observed as with crude oil. In addition, the day itself should be dry, that the rapid evaporation of the oil may be favored. The insects are killed as soon as the oil penetrates them; the earlier it disappears thereafter, the better for the tree.

Vigorous, rankly growing trees are much less susceptible to injury from oil applications than are those in which the growth is feeble and the bark hide-bound. The horticulturist who prefers to rely upon summer applications must remember that scale insects never sleep, have no Sundays or holidays and when once started breed continuously.

Persistent applications of whitewash are often very useful. Lime alone is not of much use against the scales, but if, just before the breeding begins, a thorough coating of lime wash be sprayed on the trunks and branches the young will find it impossible to set on the sprayed areas. Many indeed will be killed and many of the breeding females will be destroyed. If a coating be applied before the middle of May, the males when they hatch cannot gain access to the covered females and many will remain unimpregnated. Thus with lime alone a very decent sort of campaign may be made. The first application should be made about May 10th, the second, one month later, June 10th. Thereafter applications may be made as often as the covering becomes badly worn. A little salt adds greatly to the sticking qualities of the material. The wash should be sprayed on as is the Bordeaux or other mixture in which lime is used and it should always be strained before using.

Fig. 6—San José scales attacked by the fungus, *Sphaerostilbe coccophila*. The pale circles around the scales are the orange fruiting processes; in some cases the scales have dropped off, leaving round or oval pale spots; about four times natural size. (*From Smith, N. J. Exp. Sta. Repts.*)

WINTER WORK AND WINTER INSECTICIDES.

A tree free from foliage and in a dormant condition will stand more severe applications than can be safely applied in summer. The season is longer, outdoor farm work is largely at a stand-still, the insects are not breeding and, almost naturally, the fruit growers have preferred to fight the scale during the winter months.

But, while the tree is thus dormant and in its most resistant state, the scale insect is in the same condition. The stage in which the winter is most safely passed is as a half grown larva under the black scale. This black scale consists of a thin waxy material hardened by a lac-like substance which gives it great resisting power to ordinary solvents. The first cast skin of the insect itself now forms part of the covering, and brings an addition of chitine that makes it yet more resistant. The edge of the scale is sealed closely to the bark of the tree or other plant, and there is no perceptible opening anywhere around its margin.

To reach the insect beneath this covering we must have either a caustic that will corrode the scale or a very penetrating material that will soak through or under it.

The caustics that have approved themselves best are the lime, salt and sulphur wash on the Pacific Coast, and the whale oil soap on the Atlantic Coast. The penetrating materials are crude petroleum and refined petroleum or kerosene.

Each of these will be taken up and its action and range of usefulness defined.

LIME, SALT AND SULPHUR WASH.

This is chemically, when properly prepared, a double sulphide of lime, with an excess of lime in its composition. It is very caustic and corrosive when fresh and if it remains dry holds its caustic qualities for a considerable period of time. It decomposes slowly under such circumstances, giving off suffocating and poisonous vapors in small quantities; but acting continuously upon the insects covered by it. In the presence of moisture the caustic combinations change rapidly and dissolve out, leaving only a good coating of ordinary

whitewash which may remain intact a long time. In Central and Southern California, indeed throughout most of that State, long periods of dry weather give opportunity for the mixture to produce its maximum effect. In the moist climate of the Atlantic slope, the dry winter periods sufficient to allow the insecticide to act, are exceptional and their occurrence cannot be foretold.

A complete analysis of this material and a technical statement of just what chemical changes occur, is to be found in Bulletin No. 30, New Series, of the Division of Entomology of the U. S. Department of Agriculture. What has been said in the previous paragraph presents the result in a generalized form.

It is fair to state that in Oregon where rains are frequent, the wash is as successfully used as in California, with a different formula for its make-up. It is also well to say that in the winter of 1900-'01 the Oregon formula was satisfactorily used in Burlington county, New Jersey, while one of the Californian mixtures was successful in Washington, D. C. Mr. Marlatt had in previous years used the wash in Washington, fully as well made and applied under favorable conditions, always without satisfactory results. He attributes the success of 1900-'01 to a period of dry weather, lasting three weeks after the application was made. The New Jersey result cannot be explained in this way, for rain began before the treatment was completed. Inasmuch as in another State the same wash had been an almost absolute failure, we are left somewhat at sea as to the actual value of the material under Pennsylvania conditions. Applications will be made in New Jersey during the present winter under careful supervision on a scale large enough to determine the practical worth of the mixture in the East.*

Inasmuch as the wash is absolutely safe on peach trees, the importance of a thorough trial is obvious and as some benefit is almost certain to be derived, it may pay Pennsylvania peach growers to give it a trial.

The Oregon formula which was used in New Jersey, is as follows:

Sulphur, ground (pounds), ...	50
Lime, unslacked (pounds), ...	50
Salt, stock (pounds), ...	50

This will make 150 gallons of wash.

Slack the fifty pounds of lime in enough water to do it thoroughly, add the fifty pounds of sulphur and boil briskly for at least an hour, adding water in small quantities as necessary; then add the salt and boil hard for at least fifteen minutes more. Add hot water to make the 150 gallons and apply at a temperature of at least 100 degrees. Strain before using and apply with a Bordeaux or similar coarse nozzle.

*Since the above was written a year has passed. The wash has been extensively used and with almost uniformly good results. It has become the standard insecticide for this scale in some localities and is unreservedly recommended as best for peach trees.

The formula used by Mr. Marlatt is:

Lime, unslaked (pounds),	30
Sulphur, ground (pounds),	30
Salt, stock (pounds),	15
Water (gallons),	60

The mixture was steam boiled four hours and applied hot.

A great diversity of directions for preparing this wash appears in the Pacific Coast publications; but the essential point is that there must be a very thorough boiling for at least one hour. Two, three or even four hours are often recommended and the mixture must be hot* when applied. In all my conversation with Pacific Coast orchardists, this "long boiling" was emphasized.

Straining is always essential, and it should be noted that the wash is very corrosive. Pump and hose should be most thoroughly washed after using it and the hose will at best last only a short time. Leather, rubber or cotton packing must be well looked after in all cases.

The price of this wash, aside from the labor involved, should not exceed two cents per gallon and it may be applied at any time during the winter.

WHALE OIL SOAP.

This was the material first successfully used in Maryland in fighting the pernicious scale, and it can be usually depended upon for good results when applied at the rate of at least two pounds in one gallon of water. This is also a very caustic substance and corrodes the scales upon which it is spread. As the scales thin out, the moisture of the air dissolves the soapy coating and the mixture, in time, soaks through the covering, coming into contact with the insects below. Too much rain may wash off the soap before it has had an opportunity to produce its specific effect, and the result will be correspondingly incomplete. At any strength less than two pounds in one gallon of water, the effect will not be sufficiently complete and the tendency has been rather in the direction of using two and one-half or even three pounds of soap in the same quantity of water.

This makes a nasty mess to spray, and it should be at least warm to remain liquid enough to pass readily through the nozzle. Great thoroughness is necessary, that there may be material enough to

*This not now regarded as essential for good effects; but the mixture sprays better when warm.

penetrate through the scale masses on badly infested trees, and that it may get into the crevices and irregularities of the bark.

This strong soap mixture has one serious drawback. If applied in the early winter it almost invariably kills the entire fruit set on peach trees and a large percentage of that on other orchard trees. As spring advances the bad effect on the fruit buds becomes less marked and, if the application is made just before the trees start, little or no harm will be done. This throwing the time of treatment so far along in the opening season is a great disadvantage, because any accident to machinery, or a long streak of adverse weather, may make it impossible to complete the work in a large orchard. On peach trees even one pound to one gallon of water will injure some fruit buds if applied early in winter; but on other orchard trees this seems to be safe.

There is an incidental effect from both of the caustic mixtures described. The lime, salt and sulphur wash is a tolerably good fungicide and will kill off a very large proportion of the spores lodged on the surface of the treated trees. The soap mixture on peach trees seems to cure the leaf curl.

There are several good fish oil soaps on the market. They are called "whale oil;" but, as a matter of fact, are made chiefly from refuse fish oil. The writer has tried and can speak personally of three of these. One is made by James Good, 939 North Front street, Philadelphia, Pa., and is a soft soap. Another is made by W. H. Owens, Catawba Island, Ohio; and is also a soft soap. The third is made by Leggett and Brother, 301 Pearl street, New York City, N. Y., and is a hard soap. Mr. Good makes two kinds; one that he calls Potash No. 3, and one containing and an indeterminate quantity of tobacco extract; but otherwise the same. The tobacco adds nothing to the soap as against the San José Scale.

All these soaps are good and any one of them will answer for any of the purposes for which such soap is recommended here. The cost of all of them ranges between three and one-half and five cents per pound, dependent upon the quantity purchased. A gallon of wash would thus cost for winter applications from seven to ten cents, exclusive of freight charges and other expenses of preparation.

The effect of the material on fruit buds must be always kept in mind; but where this feature does not become important, as when trees are not of bearing age, the date of application may be anywhere between January 1st and the opening of the buds.

KEROSENE.

The results obtained with this material have been excellent so far as effectiveness against the scale is concerned. They have been extremely variable in their effect on the trees. Some of the New Jersey growers are quite satisfied with it and will continue to use it; but the majority prefer the crude petroleum.

Kerosene may be used either undiluted, in a mechanical mixture with water or in the form of an emulsion with soap.

For winter application the emulsion has proved a failure, practically; but as it is a standard mixture, the directions for making it may be here given.

Kerosene (gallons),	2
Water (gallon),	1
Hard soap, shaved fine (pound),	½

Dissolve the soap in boiling water, warm the kerosene and pour it into the boiling suds. Churn with a bucket or other force pump for about five minutes, by pumping from and into the bucket through a coarse nozzle. This will result first in a milky white mixture and soon in a thin cream that becomes difficult to pump. It will be pure white when cold and of the consistency of butter at a temperature of sixty degrees.

This emulsion contains sixty-six per cent. of kerosene and may be mixed with water to any extent; if well made it will keep, without separating, for several days. For summer applications this material has a great range of usefulness; but it is not so good against scale insects as the whale oil soap and not so satisfactory as the mechanical mixture. Rain water or other soft water should be used in making the emulsion; if only hard water is available, it should be softened with soda or borax.

A mechanical mixture of kerosene and water is made by pumping with the same stroke from a kerosene and a water tank in such proportions as is desired. The liquids join near the nozzle and are forced out together in a milky, white spray. Anywhere from ten per cent. to fifty per cent. of kerosene to a corresponding percentage of water may be thus applied and a fifteen per cent. mixture is quite effective against scale larvae and recently set scale insects. But nothing less than a fifty per cent. mixture will serve for full grown scales and even this will not always give realiable results.

Undiluted kerosene has done best for me, in my own practice and

some others have done equally well; but on the other hand, some have obtained bad results only. It seems to be very largely a matter of locality and climatic conditions. The same experimenter has sprayed peach trees safely with undiluted kerosene in one section of his State, and killed every treated tree in another. Therefore undiluted kerosene should be cautiously and experimentally used, especially on peach, until its local effect is determined. The precautions to be observed are: Spray with a very fine nozzle; use no more than enough; see that the trees are dry and that the weather is such as to favor rapid evaporation.

The cost of kerosene varies from six to ten cents per gallon according to locality. It is therefore about as expensive as whale oil soap of equal quantity; but kerosene is so much more penetrating and spreads so much better, that a given quantity will cover almost twice as much surface as the same quantity of soap suds.

Kerosene depends for its effectiveness upon its penetrating power which carries it through and under the scale, into contact with the insect below.

CRUDE PETROLEUM.

Crude petroleum is the natural product as it is obtained from the oil wells, and varies greatly in composition. I need not go into details on this point further than to say, that to be useful for insecticide purposes it should have a paraffine base and, if used undiluted, should have a specific gravity of forty-three degrees or over on the Beaume scale. I do not mean to assert that oils with an asphaltum base may not be useful; but I know nothing about them as insecticides. Therefore, whenever crude oil, or crude petroleum is mentioned in this Bulletin it must be understood as a paraffine base oil of forty-three degrees or greater specific gravity. Such oil is produced in Pennsylvania, West Virginia and Ohio, and it may be either green or amber in color.

Crude oil contains the light napthas, the somewhat heavier illuminating oils, and, in addition, a variable quantity of paraffine and vaseline. When it is sprayed on a smooth surface so as to make a thin covering, the light oils evaporate in a very short time, leaving a film of greasy material which is the vaseline and paraffine. If the surface be non-absorbent this film will remain indefinitely through heat and cold, provided dust be excluded. In the heat it will thin out a little;

in the cold it will thicken. If dust be admitted it will adhere to the greasy surface until a layer is formed so thick that all the fatty matter is absorbed in it. If the surface covered by the film be absorbent every particle of the vaseline will find its way into the absorbent material unless a dusty or other covering absorbs it.

Precisely this happens when a tree is sprayed with crude oil. The light oil is very penetrating, and soaks at once through the scaly scurf, carrying down also the vaseline and wax into contact with the insect. In a very short time this light oil is gone and the greasy coating alone remains: the scales absorb and hold this. On trees with a smooth, waxy bark like certain pears, the surface is not absorbent, the coating remains and no young scales can set until, by growth, uncovered bark appears, or until the dust has taken up the grease and the coating rubs or flakes off.

On peach, the bark is absorbent except on the newest shoots, and whatever vaseline is left after soaking the scales gets into the plant tissue. If the bark is coarse and thick and the vaseline film thin, no harm is done; the inert outer layer takes it all. If the bark is thin and sensitive and the coating thick, the vaseline will replace the contents of the plant cells and kill them. It will continue to penetrate until it is all absorbed and so we have kills. In Southern States the bark on peach is more sensitive and thinner than in the North; hence oil, unless carefully used, is dangerous or fatal. In the latitude of Philadelphia it is safe with reasonable care.

I have been thus explicit concerning the crude oil because I believe it to be the most effective material thus far employed against the scale, and reasonably safe for all trees when its use is understood.

The killing power is not only in the light oils, but in the vaseline residue; in fact, coating an infested bark with vaseline would result in the death of every covered scale; probably also in the death of the tree.

I have treated all the ordinary orchard trees with crude oil at all periods from recent dormancy to just starting and never killed a tree. I have killed peach buds by soaking them with oil, from a brush, but secured a full crop after spraying in October. I first sprayed and afterward painted a young peach and had a full show of flowers next spring. So I have drenched an apple by letting the oil run down from the tips of the twigs until the whole tree had as much oil as would stay on it. I killed the outer layer of bark on the trunk and large branches; but this flaked off, leaving a beautifully smooth bark underneath. The tree was as badly infested as it could well be and a few twigs died from the combination of oil and scale; but not a bit of real injury was done. Yet I know that others have been less fortunate. One careful man finds it almost impossible to use the oil safely on Ben Davis apples; another who lives not ten miles away

from him declares that it is impossible to hurt Ben Davis no matter how much oil you put on.

Mr. John Repp, of Glassboro, N. J., used 1,000 gallons of oil, undiluted, during the winter of 1900-'01, without hurting a tree; and his case is not exceptional.

In the peach district of North Jersey the crude oil, used in a mechanical mixture with seventy-five per cent. of water, finds most favor, and this seems to be the result of experiments made on peach by others.

In a mechanical mixture containing twenty-five per cent. of oil, each particle of oil is accompanied by three particles of water, and if the spraying be as carefully done as with undiluted oil, the same amount of oil is made to cover four times as much surface. As the water evaporates or is absorbed, the vaseline and paraffine remain; but the coating is only one-fourth of what it would be were the oil applied pure.

It must be remembered that the *oil* is the killing agent and there *must* be enough to kill the insects. The water simply spreads the same amount of killing material over a larger surface. The evidence seems to be in favor of the effectiveness of the twenty-five per cent. mixture and its safety on trees. It may pay the careful man to experiment a little, especially as for this a lower grade oil may be used.

It makes a difference on peach as to the time when the oil is applied. Trees treated in January have been killed where others in adjoining rows, treated in March, were unhurt. Bark completely dormant is probably more absorbent than that in which the sap is rising. On apple, pear or plum, it makes little difference at what time of the winter the application is made. Fruit buds will not be harmed by any reasonable covering. Yet I would not recommend treatment to be made before January. So I would prefer to have trimming done after the spraying, for if done before, the cut surfaces would absorb a certain amount of oil. If the cutting is close to the branch this absorption may cause injury; but if one-half to one inch stubs are left, no harm will be caused and the trimming may be done before the spraying.

As to the price of the crude oil, that has varied from season to season and will vary in Pennsylvania in proportion to accessibility. In New Jersey, the Standard Oil Company demands thirteen cents per gallon and gets it. For this they furnish a green oil,—Insecticide oil they call it,—that tests forty-four degrees or very close to it. In Ohio, oil testing as low as thirty-five degrees has been safely used in a twenty per cent. mechanical mixture. I would be afraid of oil so low in grade; but forty degrees or possibly thirty-eight degrees might be safe in a twenty-five per cent. mixture if there is a material difference in price.

SUGGESTIONS FOR PRACTICE.

From the information given in the preceding pages, the fruit grower should be able to determine upon his plan of campaign against the pernicious scale; but a few suggestions based upon practical experience may not be amiss.

If the grower does the work himself, he can get along with crude oil only. If he must depend more or less upon hired help, whale oil soap should be on hand for the summer applications unless he prefers lime. At least once a month—better once every two weeks—every tree in the orchard should be looked at closely enough to note any serious increase in the scales. Whenever larvae are noted in such numbers as to render injury probable, the tree should be marked for immediate attention and this attention should be given—not merely intended. Whale oil soap, lime or crude oil may be used as indicated under the head of summer treatments. The inspection in late September or early October should be especially close, to lessen the number of scales that are to be reached by winter treatment. I do not suggest treatment whenever larvae re seen on a tree, unless summer work is to be altogether relied upon; only when the insects occur in dangerous swarms. Spraying should not be done when the fruit is nearing maturity, especially in peach; but should be done, if needed, soon afterward, to prevent a drain that may interfere with the setting of fruit buds.

When the foliage is all off, or at any time in December, a systematic and careful inspection should be made to determine what trees should be treated. I am by no means in favor of dosing every tree because here and there a scale may be detected. Where scales are well distributed over a tree, treat by all means; but if only a few examples can be found by close search, give the tree another year.

In all except peach orchards I would unhesitatingly suggest crude petroleum for the winter treatment. Pears may be treated first, any time after the beginning of January. Plums may follow next. Apples had better come in February, and if peaches are also to be treated, let them come last, in March. My personal preference is in favor of the undiluted oil, carefully applied, for the following reasons: The oil alone kills; if only oil is applied, every particle is effective; if oil and water are applied there are three or four ineffective particles and where these strike, no benefit will be derived; any carelessness that results in the irregular action of the emulsion pump produces

irregularity in results. Yet on peach it may be safer to apply the twenty-five per cent. mechanical mixture, unless either the lime, salt and sulphur or the soap mixture is preferred.* The former may be applied any time when a dry spell seems likely. The latter should be delayed just as long as it is safe to do so.

If undiluted oil is used, it should not be too cold. It is very fluid at ordinary temperatures but thickens a little when they are low. The oil is a bad conductor and if a barrel comes from a room at sixty degrees, it can be completely sprayed out before it loses very much, even in a freezing temperature.

The horticulturist must ever be observing, ready to act at a moments notice, persistent in the fight, ready to take advantage of any opportunity to lessen the pest and studious to find what is the best practice in his own surroundings. He must not be afraid to try experiments and should not allow an occasional failure to discourage him.

The man who brings the most intelligent consideration to bear upon his own case will be most successful in the end.

MACHINERY AND HOW TO USE IT.

The important point to be looked to, if oil is to be used, is the nozzle. Any good pump will do to supply the power; but there must be a Vermorel nozzle with a fine tip to distribute the material. This should be so, even if a mechanical mixture is used. On large trees a group of two nozzles or even a triplet may be used; but always get the cap with the smallest opening. A gas pipe spraying rod ten feet long is an excellent bit of accessory apparatus and it should have a shut off at the bottom.

For whale oil soap, a Vermorel nozzel with an opening of larger size may be used; or a Seneca, Bordeaux or McGowan nozzle will answer. For lime, salt and sulphur the Bordeaux nozzle is especially suitable, but there are others that will serve almost equally well.

The Vermorel nozzle may be obtained from all makers of insecticide machinery, and almost every one of these has something that corresponds with the Bordeaux nozzle, throwing an adjustible, fan-shaped spray. It is important that a nozzle for the lime wash be easily cleaned in case it becomes obstructed.

As to the pump for straight forward spraying, there are so many good machines on the market that it is unjust to recommend any one

*The lime, salt and sulphur wash is now recommended in preference to all others.

make over all others. Every agricultural paper has the advertisements of half a dozen makers and each will readily send descriptive catalogues.

Each man must select a pump according to his needs and he should remember that, while a powerful pump can be made to do a little work, it is not possible to make a weak pump do work beyond its capacity. Be sure to get one fully equal to your needs.

For orchard work, it is economy to have a good pump of large capacity that may be mounted on a barrel, on a tank wagon or even on a wagon platform with a suction hose to go into the barrels of spray mixture.

A good pump is one in which the valves and all the working parts are of brass, which is simple in construction, has a good sized air chamber, metal packing, a stout wrought iron frame, and a good leverage. Rubber is objectionable if oils are to be used, but leather is admissible. For the caustic washes, especially the lime, salt and sulphur, neither rubber, leather nor cotton will prove lasting.

Besides a pump of large capacity, a knapsack pump is often useful in orchard work, especially among young or dwarfed trees. Particu larly is this so when summer treatments are to be made. The knapsack pump should have a detachable oil tank for applying mechanical mixtures of oil and water.

Of the emulsion pumps, only two types are known to me that come up to reasonable demands. One series is made by the Goulds Manufacturing Company, Seneca Falls, N. Y., the other is made by the Spramotor Company, London, Ontario, Canada. Both of these are good and both come in various sizes and styles, from which the purchaser must select that which best suits him. In using these emulsion pumps a few simple rules must be observed to make their work reliable.

Work the lever evenly and, so far as possible, continuously. If spraying must be stopped, shut off both pumps at the base attachment. Never allow either oil or water to get below the suction point. Attention to these details may make all the differences between success and failure.

As to prices for machinery, these vary so much that no safe estimate can be given. It depends upon the accessories needed and upon the demand to be made upon the machine. A good pump is always a cheap pump; but a cheap pump is not always one that costs least money.

THE NURSERY PROBLEM.

The agency of nurseries as distributors of insect pests has been elsewhere dwelt upon. The methods to be adopted to prevent this distribution are matters of control by the State authorities and not within the scope of this article.

Experiments have shown that so far as the pernicious scale is concerned, stock may be thoroughly cleared of it by careful fumigation with hydrocyanic acid gas. As this destroys also many other fruit pests, it is not an unreasonable requirement that nurserymen should fumigate all their fruit stock before sending it out.

Fumigation as here used, means exposing the dormant stock to the action of the gas in a properly constructed room or building, for a time sufficiently long to kill the pernicious scale.

A properly constructed room or house is one that is gas tight. It is best made of wood, may be of any desired size or shape, should have double walls with building paper between, should be ceiled with tongued and grooved stuff closely fitted and should have closely fitted doors and one window to be closed and opened from without. There need be no flooring; but unless the stock is fumigated on a wagon backed into the house, there should be a slat floor a foot above the ground. In the center there should be a place for the gas generator which may rest upon the ground. If a wagon is used, the generator may go under the wagon. The space below the slat floor is to allow the diffusion of the gas in every direction. The stock should not be packed too tightly and should be so arranged that toward each corner there should be a tolerably open chimney or passage through which the gas may get to the ceiling.

The formula for each 100 cubic space is:

Cyanide of potassium, 98 per cent. pure, by weight,	1 oz.
Sulphuric acid, sp. gr. 1.83, by measure, ...	2 oz.
Water, ...	4 oz.

Pour the acid slowly into the water and when everything is ready, drop the cyanide, broken into small lumps, into the mixture. In a small house, the cyanide in a paper bag can be dropped by hand into the jar and before this bag is penetrated the operator can get out and close the doors. In a large house, with considerable stock, the bag of cyanide may be suspended over the jar by a string, attached near the doors. When the doors are ready to close, release the cord that the bag of cyanide may drop into the dilute acid and close the doors

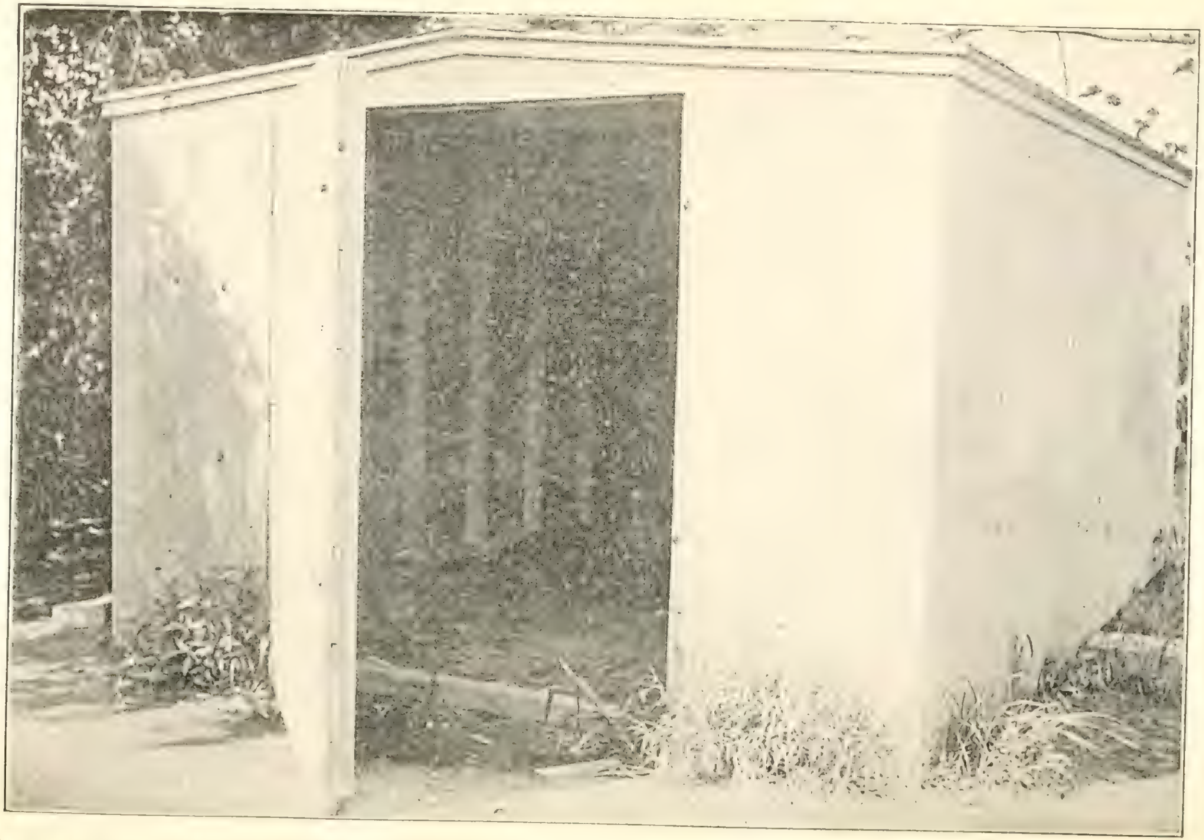


Fig. 7—A properly constructed fumigating house; note the edge of the door. Size 16x10x7 feet. (*From Smith, N. J. Exp. Sta. Repts.*)

tightly. The jar may be any glazed earthenware vessel, sufficiently large to hold double the amount of liquid necessary. This is to avoid slopping or sputtering over, when the formation of the gas begins. Fully dormant stock may be safely exposed one hour or more. Apple and pear will stand a much longer period. Peach is most sensitive and, if the exposure is to be a long one, the amount of material used should be reduced one-fourth. At that strength a house may be left closed all night. The essential points are an absolutely tight house; the generator in the middle and a chance for the gas to reach all parts of the room readily.

It should be remembered that all the materials used to produce this gas are violent poisons and the gas itself is extremely poisonous. Care should be taken not to inhale any of it and, when the fumigating house is opened, this should be done from the outside in such a way as not to get the first whiff from within. The one needed window should be opposite the door, and both doors and window should be open for at least ten minutes before the house is entered.

Infested stock thus fumigated has been planted out, closely watched and found free after three years. The effect is absolute if the work is well done and therefore it is well within the police power of the State to require the nurseryman to erect and maintain a proper fumigating plant, and to see that he understands its use. The nurseryman should not be hampered in his business more than is absolutely necessary to protect his customer, and this is a limitation that my experience with the trade leads me to believe will be acceptable.

FINALLY.

While the San José or Pernicious Scale is a most destructive insect, it has its good side. Its advent has stimulated the horticulturist to a closer study of his subject. It will drive out the incompetent and unintelligent grower by killing his trees. It will tend to the production of more limited crops of better fruit, for which better prices may be obtained.

And, after all, we can control the insect if we set out earnestly to do it. If we cannot grow fruit without it, we can do so in spite of it. It has been and is being done in New Jersey.

CANNING OF FRUITS AND VEGETABLES.

By Prof. George C. Butz, *State College, Pa.*

THE CANNING INDUSTRY.

The enormous quantity of canned goods that is annually put up by American factories is astounding, to say the least, and when considered commercially, is well worthy the distinction of an industry. The pioneers in the business may have hesitated to invest largely in this stock, but it is certain now that the canning industry is on as permanent a basis as is the iron or coal industry. The successful preserving of fruits and vegetables in tin wrappers in quantities to supply the world and for a price that will carry the goods into the humblest home, has been demonstrated by the experience of more than a quarter of a century. The demand for canned goods steadily increases from year to year, and it may be said even now that a large part of our population is wholly depending upon the canner for the fruit and vegetable part of their diet. This is true not only of the millions who dwell in tenements and other thickly populated portions of our cities, but also of other millions who formerly grew their fruits and vegetables in private gardens and abandoned them in favor of the canned articles which may be had at a less cost and with less labor.

A steady increase in population requiring increased quantities of foods, the introduction of special machinery to economize labor and cheapen production, and the tendency of men to engage in special and limited lines of work, force us to admit our mutual dependence for the products of each others labors. And so the canning industry has attracted to itself the men who are specially qualified to prepare and preserve certain foods which could not be enjoyed by millions of their fellowmen, except for this art of canning. The demand for canned goods will continue to grow and it is next to impossible to estimate the probable development of the next quarter of a century. The growth of the business done in the past decade is a pretty fair index of what may be expected in the future. In the reports published by the *American Grocer*, the total packs in America of tomatoes and corn for the past ten years are expressed in figures as follows:

TOMATOES.

Year.	Total pack cases of 2 dozen tins each.	Lowest price per dozen.	Highest price per dozen.
1890,	3,166,177	.77½	$1.00
1891,	3,405,365	.80	.85
1892,	3,366,792	.82½	1.00
1893,	4,635,183	.95	1.45
1894,	6,586,979	.70	1.10
1895,	4,194,780	.60	.75
1896,	3,541,188	.57½	.80
1897,	4,194,780	.60	1.00
1898,	5,797,806	.80	1.15
1899,	7,404,923	.70	.85
1900,	5,849,593	.65	.80

CORN.

Year.	Total pack cases of 2 dozen tins each.	Lowest price per dozen.	Highest price per dozen.
1890,	1,588,860	.60	$1.10
1891,	2,889,123	.95	1.20
1892,	3,371,079	.95	1.25
1893,	4,301,451	.80	1.10
1894,	3,414,888	.65	.85
1895,	3,121,164	.55	.75
1896,	2,676,515	.50	.75
1897,	2,968,740	.50	.85
1898,	4,448,563	.60	.75
1899,	5,440,920	.62½	.80
1900,	6,485,624	.62½	.80

The permanence of a business dealing with such quantities cannot be questioned. It may be remarked also that the total output of the canning factories of this country in vegetables and fruits is practically all consumed within our own boundaries. The foreign shipments have been small, simply because the home consumption has held all the goods in this country. *The Trade*, of Baltimore, a journal for canners and grocers, in a weekly review of September, 1901, says:

"Meat has for many years been one of the steady articles of supply which the new world has sent to the old. Fish in the form of salmon and sardines, to say nothing of oysters and barreled fish, have furnished vast amounts of exports to foreign people, and it is as certain as the rising and setting of the sun that canned goods will yet form a vast amount of exports from America to Europe. If Europe, however, counts upon America for any exports of canned vegetables and fruits this year, she will have to be prepared to compete with our home consumers for what she gets. There will be no surplus of anything this year for exports."

It is difficult to obtain statistics of the latest pack because the packers are not inclined to tell their output for fear of influencing the market against them.

THE HISTORY OF THE DEVELOPMENT OF CANNING VEGETABLE PRODUCTS.

When we look for the beginning of canning fruits and vegetables, we find the credit and honor of the discovery is accorded to a Frenchman named Appert, who in 1810 published under the authority of the French government the results of his experiments in preserving fruits in air-tight packages after boiling. As early as 1819, Thos. Kensett, who probably learned the art before leaving England, is known to have put up canned goods in New York in partnership with Ezra Daggett. This firm obtained a patent in 1825 for an improved method in the art of preserving, from the United States government. During the subsequent fifteen years other attempts at preserving fruits, vegetables and fish were made in several quarters along the eastern coast, but they were not all successful. Isaac Winslow, of Portland, Maine, began his experiments in canning sweet corn in 1839; at first he boiled the whole ears without satisfactory results. He then cut the corn from the cob before boiling, but was disappointed to find, later, that nearly every can swelled. He persisted, however, in his effort to find the error of his ways and after many years of failure and partial successes he perfected his methods and

secured a patent for it from the United States in 1862, several years after the application had been made. Isaac Winslow was the first to pack sweet corn in cans for sale. In 1847 the first tomatoes were packed for sale. This was in New Jersey. It was not long before small canning factories were established in several States east and west, but many reverses were met with from time to time to discourage very extensive packing. As late as 1878, the corn packers of Maine lost their entire output by having it spoil, for a reason which they could not then discover. E. D. Duckwall referring to this event in his "Bacteriology" of canning in 1899 says: "The few manufacturers in Maine at that time suddenly had a very rough experience in 1878, when the entire output spoiled, nor were they ever afterwards able to sterilize their cans by the boiling process. Capital had been invested, and the business had been growing rapidly before, and now every thing seemed to be lost. New locations were tried, longer times of boiling were given, but without avail; the corn seemed to have changed into a new product which would not keep. Some manufacturers sent samples to chemists for analysis to find out what caused the trouble, but the real cause not being known they could not give the manufacturers any information of practical value, except that the spoiled corn contained small round globules which were not dissolved by boiling heat." Such experiences kept canners shy of making heavy investments until a closer study of the difficulties brought about such modification of the processing of corn that "swells" became infrequent and are now reduced to a very small fraction of the pack.

Twenty-five years ago the demand for canned goods became brisk and factories were springing up in many of the States, prominently in Maine, New York, New Jersey and Maryland, the last named being a strong leader in the industry for several years. In 1890, it is reported that 20,000 factories were in operation in the United States, and it is very probable that the late census will show that the number has more than doubled with greatly increased facilities.

CO-OPERATIVE CANNERIES.

In recent years, agents of canning machinery manufacturers have visited rural communities to induce farmers to organize themselves into companies to grow vegetables and erect a canning factory to pack the crops. All encouraging information was freely given and the so-called "secrets" of canning were promised in the event of organization. The agent was interested only to the extent of making a sale of the factory outfit for which, often, an exorbitant price was charged. It stands to the credit of the farmers, however, that

but few such factories were established, probably the sad experiences of the co-operative creameries restrained them from venturing upon anything that had the word "co-operative" attached to it.

INDIVIDUAL MANAGEMENT.

The nature of canned goods is such that the management of the business of the factory is most successfully conducted when it is reposed in one responsible head. The person chosen may represent a company, but he should be possessed of such business traits that all confidence may be placed in his ability to buy materials and sell goods. He must have in his employment a "processor" whose experience will bespeak a successful pack. Such men are paid from $50 to $150 per month, according to their qualifications. The work of the processor requires the greatest amount of skill, and while formerly a great degree of mystery was thrown about his work to guard the "secrets" of canning, it is now well known that there are no secrets, except where the use of preservatives forbidden by law is practiced. Canners have learned that it is better for them to throw open their factories to visitors, permit the closest inspection of their operations and disclaim any secrets, and thus retain the confidence of the people in the cleanness, wholesomeness and purity of the foods they can. No person can steal a processor's skill by a visit to his factory; nor can one equal the capper's speed by watching him at his work.

Farmer's are benefited by having canning factories operating in their section of country, as they find it more profitable to grow tomatoes, corn or peas for the canner than by growing any other crop. The basis of calculation is upon present prices paid for raw materials. The yield of tomatoes varies greatly in different years and soils. It may be considered as coming somewhere between 8 and 16 tons per acre, a fair average yield being 12 tons or about 400 bushels. During the past season farmers contracted to supply tomatoes to the factory at $6 per ton, but owing to the unfavorable conditions existing in September, many canners were eager to get tomatoes at a much higher figure.

Corn does not figure so well. The yield from good land is about 4 tons per acre for which the canner pays about $6 per ton. Where corn is being extensively canned, as in New York and Maine, the farmers count it a little more profitable to grow sweet corn for the canner than to devote the same land to their usual crops.

Peas of the varieties grown for canning will yield 75 to 100 bushels per acre. Packers pay from 75 cents to $1.25 per bushel. The farmers of Delaware when peas are extensively canned, realize an average net profit of $20 per acre, after accounting for labor, seed and fertilizer.

LOCATION OF CANNING FACTORIES.

There are several important considerations that determine the proper location of a factory. While there are a number of large factories in the principal cities, the great majority of them are in the small towns scattered over the country districts. Here the canner is in close proximity to the vegetables or fruits which he calculates to pack, and he may have them delivered at his factory in the freshest possible condition. Too much stress cannot be laid upon this consideration, for the quality of canned goods depends largely upon the condition of the raw material at the time of canning. If fruits and vegetables must be bruised and heated by much handling and close packing for transportation, they cannot be expected to turn out of the cans with as fine an appearance and flavor as the goods that does not suffer such injury. The many establishments in the cities take advantage of the great surplus of vegetables and fruits that constantly pour into the markets and being perishable must be sold at any price.

If a locality possesses a soil and climate adapted to the growing of such vegetables and fruits that it is desired to possess, it is a simple matter to induce the farmers of the region to plant and grow them when a profitable market is in sight. The farmers of Pennsylvania have long felt that they must find a crop to take the place of so much wheat, which it is no longer profitable for them to grow. Wherever factories have been successfully conducted, the farmers have been pleased with their experience in growing and supplying the raw materials, and they have profited greatly by the changes brought about by the establishing of a canning factory. The two vegetables most extensively canned are tomatoes and sweet corn, and neither is very exacting as to the character of its soil, therefore, one needs not travel far to find a suitable locality for a factory so far as the soil is concerned.

Transportation Facilities.—The facilities for carrying goods to the centres of trade have much to do with the success of a canning business. Therefore it is desirable to choose a location with railroad and telegraph or telephone communications. Without railroads a canning factory cannot draw the raw materials more than a few miles and its possible output would be exceedingly limited, and the marketing of its goods very expensive. On the other hand, with railroad facilities the raw materials may be drawn from a much larger territory, and the cased goods can be placed in the markets at the least expense. If a private side track of railroad can be placed close to the factory, much time and labor may be economized in the loading and unloading of materials shipped and received. The ware-

room in which the cased goods is stored may also be conveniently located along the side track.

Water Supply.—An abundant supply of pure water is constantly needed during canning operations. Materials must be washed or scalded, utensils and machinery kept clean, and in the processing so much steam is used up that the boiler requires frequent replenishing with water.

Laborers.—It is also well to consider the matter of securing the necessary help to carry on the operations of canning to the fullest capacity of the factory. If the factory can be located where the community can supply sufficient hands, men and women, to successfully operate it the difficulties that attend the employment of non-residents will not be met with. The great bulk of canned fruits and vegetables is put up within three months and during that time the perishable goods are brought to the factories in immense quantities. At such a time a single day's idleness or insufficient help, will entail a great loss to the business. About 10 hands (unskilled), will be needed to run a factory of 2,000 cans per day capacity.

CAPITAL REQUIRED.

The amount of capital necessary to properly conduct a canning business may be much or little, according to the capacity of the factory and the variety of goods to be canned. There have been remarkable financial successes in this business, but equally remarkable failures also, and the latter have frequently been attributed to insufficient capital forcing the sale of the entire stock of goods when the market price is low. With sufficient capital to carry the larger part of the stock until there is a real demand for it, a fair profit will be realized and dividends may be declared. For instance, a small factory for canning tomatoes, with a capacity of 2,000 cans per day may put up 80,000 cans by operating 40 days. It will have a building and outfit of machinery and tools costing about $700. The cans will cost $1,600, the tomatoes $1,000 and the skilled and unskilled labor for forty days will cost $650, sundry items of expense $50, making in all a total of $4,000. If such a concern is capitalized at $2,000 with the expectation of making quick sales to pay for materials consumed, it may be forced to sell the entire pack at almost cost to meet its obligations and then find no profit in the investment, but with a capital of $3,000 or better, $4,000, labor may be promptly paid, the farmer will be made happy with his cash and all materials will be paid for at cash prices. The canner is then independent with his pack and can wait for a market that will pay him a profit of 10, 15 or even 20 cents per dozen cans of his tomatoes and he has realized from 20 to 30 per cent. upon his investment and owns his factory clear of debt.

Several of the largest canning establishments are capitalized with over a million dollars, and operate many factories running night and day during the busy season, each factory at its best turning out 50,000 cans per day. Such large concerns are developed only after years of experience in the management of smaller establishments. This brief bulletin is prepared to meet the queries of persons seeking their first information about the canning business, and not as a guide to the experts.

The small canning factories putting up a limited quantity of but one line of goods are better able than a large factory to give the closest attention to details and thus can insure an excellent quality in what they pack. Many of these factories contract to put up goods for large factories and thus dispose at once of the entire pack. A fair price may be secured in this way, but large profits due to real or fictitious "short supply" reports are sacrificed to the larger speculator in the goods.

The jobbers in canned goods are often responsible for extreme fluctuations in the market, and the small packer having no opportunity to know the exact condition of the supply is induced to sell on a very small margin of profit. The packer should keep himself informed concerning the true state of affairs with information from the most reliable sources, that he may protect his interests against the misrepresentations of speculators. Much canned goods is sold at first hand below cost, simply because the packer could not afford to hold his goods until an apparent glut was removed.

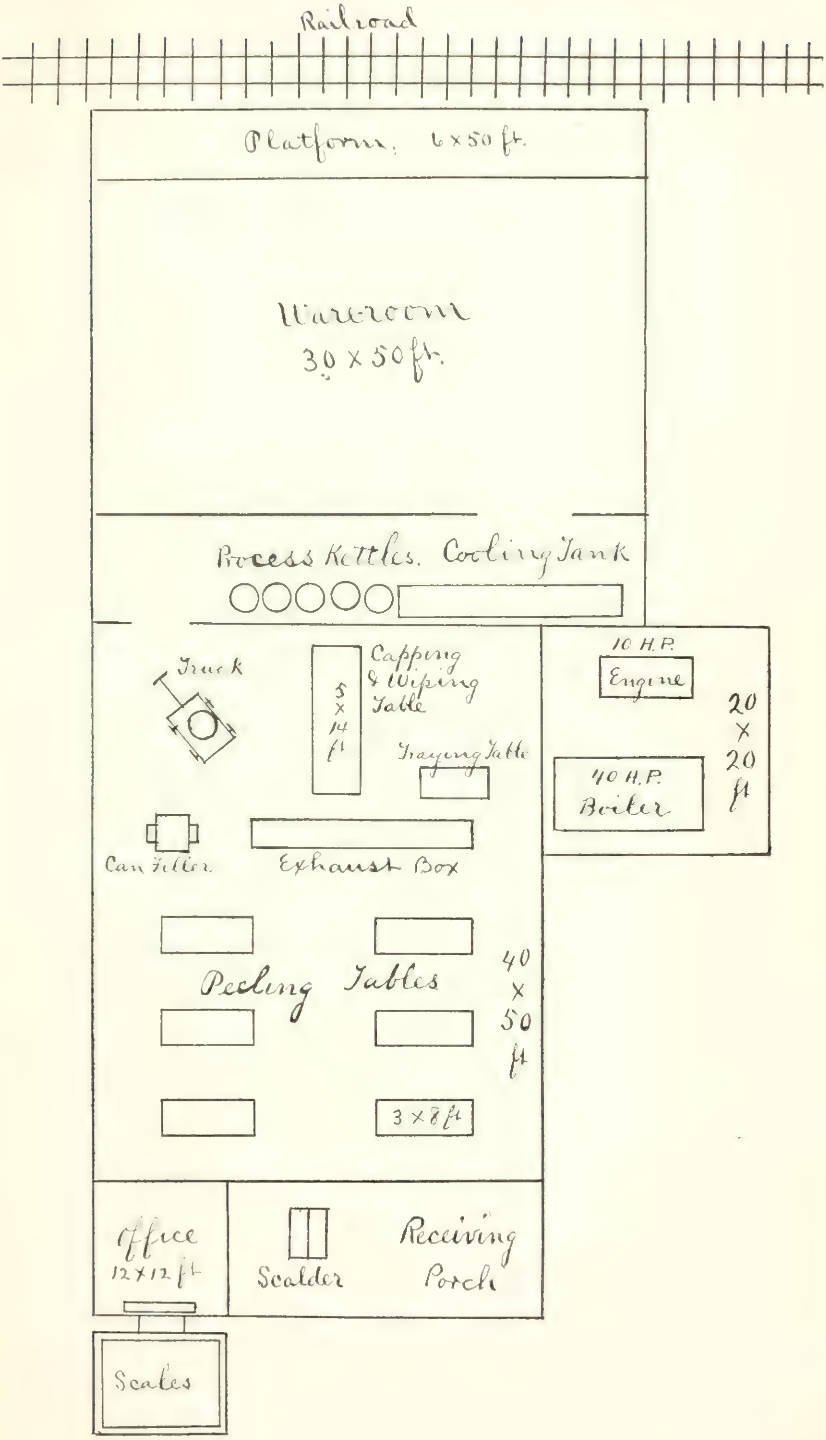
As an illustration of a remarkable development of a great establishment from a small beginning, we need only turn to the famous pickling and preserving house in our own State, that of H. J. Heinz Company, at Pittsburg, Pa. They write that "In 1869 the present business of H. J. Heinz Company was founded in Sharpsburg, a little suburb of Pittsburg, Pa., on three-quarters of an acre sown with horse-radish. The founder of the company was its entire force of cultivators, and two young girls were its manufacturing staff—grating the horse-radish for market. A common wheelbarrow was the only vehicle used by the company for marketing its products, and the entire manufacturing was done in a small two story brick building. At the present day the expanded company is planting 18,000 acres with its own seeds and gathering the fruits of many thousand acres more. Its main plant at Pittsburg, Pa., occupies 17 large buildings, and it has 38 salting stations, 9 branch factories and 26 branch warehouses and offices, and employs steadily over 2,500 workers. Its original wheelbarrow has expanded into huge drays and speedy automobiles and a host of Heinz refrigerator and tank cars running throughout the United States." Inspection of this magnificent plant is invited and every courtesy is extended.

ARRANGEMENT AND PLAN OF FACTORY.

Whatever capacity of factory may be planned for, the dimensions of the building should be ample enough to permit the most convenient disposition of tables and kettles, so that there shall be no undue crowding of the workmen, and at the same time to secure such a compact arrangement that no unnecessary traveling is called for in passing from one step to another in the operations. A building 20x40 feet, two stories, will accommodate the outfit and necessary workmen for a capacity of 2,000 cans of tomatoes per day. For a capacity of 10,000 cans per day, the floor dimensions of the building should be 30x75 feet. The plan is not necessarily a rectangle. It may be more convenient to make the structure in the form of an L. For a capacity of 20,000 cans per day with the machinery for canning fruits, vegetables and meats, a building 50x100 feet would afford ample room. This, however, does not make allowance for a wareroom, which should have about an equivalent space.

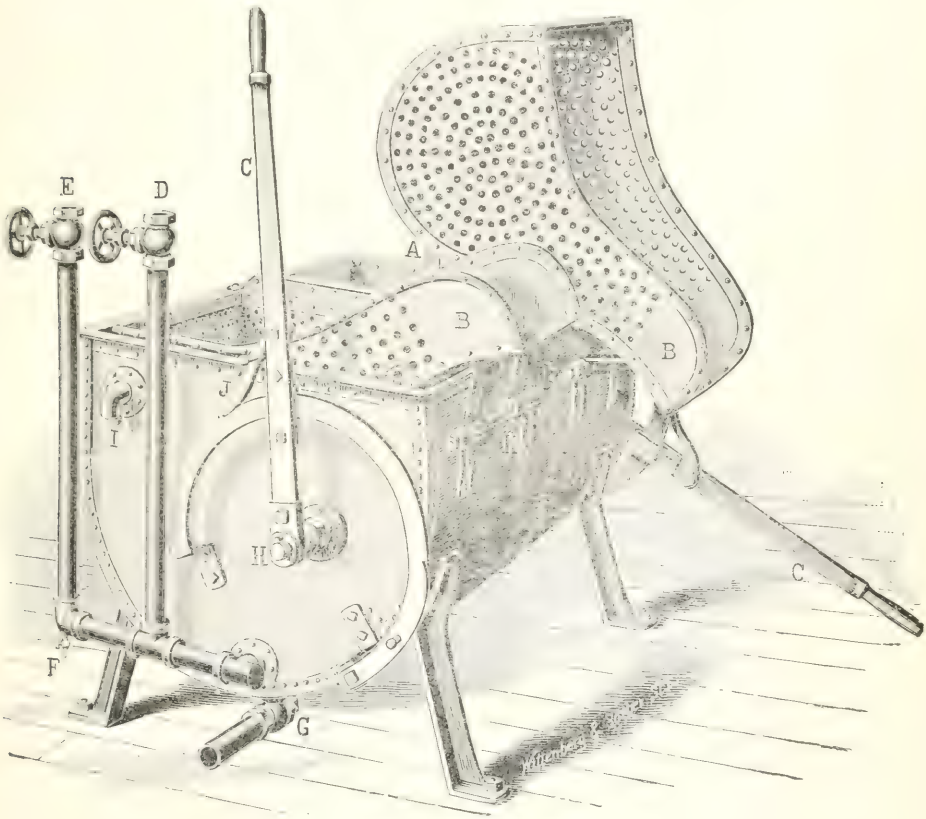
The plan should permit wagons bringing raw materials to pass over scales, to make record of the weight of each delivery before reaching the receiving platform. Close to this supply is placed the scalding kettle in which the first step in canning tomatoes is taken. From here they are placed upon the peeling tables to be peeled. This is work that must be done by hand and for which women are usually employed. The peeled tomatoes are passed to the packing tables if the cans are filled by hand, or to the hopper of the filler if a machine is used. The cans are then capped upon the capping table, tested in the exhaust kettle and when effectually sealed they are submitted to the cooking process in the process kettle. After the cans are cooled, which may be hastened by passing through cold water, they are temporarily placed in cases and stored until a suitable time for labeling. It is evident, therefore, that much time and labor may be economized by so arranging the tables, kettles and other apparatus to admit the simplest handling from step to step in the series of operations.

The firms supplying canning machinery are prepared to submit designs for any style of factory to suit any set of conditions that may be proposed to them, and the cost of the structure can be estimated by a local builder.


Railroad
Platform, 6 x 50 ft.
Wareroom
30 x 50 ft.
Process Kettles.
Cooling Tank
Truck
Capping
& Wiping
Table
5
x
14
ft
Traying Table
Can Filler.
Exhaust Box
10 H.P.
Engine
20
x
20
ft
40 H.P.
Boiler
Peeling Tables
40
x
50
ft
3 x 8 ft
Office
12 x 12 ft
Scalder
Receiving
Porch
Scales

CANNING FACTORY OUTFITS AND SPECIAL MACHINERY.

The simplest outfit for a canning factory is that used for canning tomatoes at the rate of 2,000 cans per day. For this it is customary to have a *15 H. P. boiler* to furnish steam for heating the water in the scalding kettle, the exhaust and process kettles; but a number of small factories are operated without a boiler by heating the kettles over a furnace. A *scalding kettle* is usually of cast iron with a



Double Dump Scalder.

capacity for 60 gallons. Into this the tomatoes are dipped by means of *scalding baskets* which are made of galvanized iron wire and hold a bushel. The *peeling tables* come next into use to hold the scalded tomatoes. Here about 9 women peel the tomatoes and put them into 14 quart indurated fibre buckets, of which about 2 dozen should be kept on hand. At least 2 dozen *peeling knives* are needed at this table. A *packing table* comes next into use, where the tomatoes are placed in the cans. As the cans are filled they are placed on the *capping table*, where with *capping steels* the tin caps are soldered on and the air vent is tipped with tipping coppers. On this

table or convenient to it is placed a *gasoline fire pot* to heat the soldering tools. The next requirement is the *exhaust crate* made of strap iron in which the cans are placed in a single tier and which by means of a *crane* is lowered into the *exhaust kettle* to drive out the cold air. *Can tongs* are used to remove cans if necessary while they are hot, and lastly the process crate is used to carry two tiers of cans into the *process kettle* for the final boiling. A complete list of such an outfit is as follows:

Outfit for tomato canning plant 2,000 3 lb. cans capacity *per day*. Without boiler, kettles bricked in, heating by furnace.

1 Cast iron scalding kettle, 60 gallons.
1 Exhaust kettle, boiler iron, diameter 36 inches, depth 24 inches.
1 Process kettle, boiler iron, diameter 36 inches, depth 24 inches.
4 Scalding baskets.
2 Exhaust crates, 1 tier.
2 Process crates, 2 tiers.
3 Sets of grate bars.
3 Furnace doors.
1 Crane, complete.
1 20 gallon gasoline tank.
1 Air pump for gasoline tank.
1 Air gauge for gasoline tank.
1 Gasoline fire pot.
1 Floor truck.
4 Capping steels.
4 Tipping coppers.
1 Forging stake.
1 Vise.
1 Thermometer.
1 Platform scale.
2 Can tongs.
5 Dozen peeling knives.
1 Syrup gauge.
1 Hammer.
24 Buckets, 14 quarts.
6 Capping trays.
2 Peeling tables, 2x10 feet.
1 Packing table, 3½x8 feet.
1 Capping table 3x8 feet.

The estimated cost of this outfit when supplied by any of the reputable houses dealing in canning machinery, is $210. If the boiler is used instead of the furnace, the cost of the outfit would exceed $450.

INCREASING CAPACITY.

If success attends the management of a small factory and the experience of a few years warrants expansion, it is not a difficult matter to introduce the modern machinery which has reached a high degree of perfection and is made to replace most of the hand labor of the small factory. In a factory with a capacity of 40,000 cans per day we find two 60 H.P. boilers to supply steam and power instead of one 15 H. P. boiler, a power scalding machine that will do the work of ten men, a platform conveyor for the peeling tables to carry the peeled fruit to the filling machine. The Lockwood Gang Tomato Filler easily fills 40,000 cans in ten hours. This outfit includes also special machinery for capping the cans and a sufficient number of process kettles to do the cooking as fast as the filled cans can be furnished. Such machinery is expensive, but when it is run at its full capacity the cost of canning is greatly reduced. When special lines of goods are to be canned in large quantities, it becomes necessary to have special machinery, as for instance, for corn there is needed one or more *corn cutting machines*. These machines cut the green corn from the cob more perfectly than can be done by hand, and receive the ears as rapidly as an operator can place them in position in the trough that feeds the knives. Such machines cost from $150 to $300 according to the style and capacity. A *corn silking machine* is used to remove the silk and bits of cob from the corn after it is cut from the cob, such machines vary in price from $50 to $200 each.

In large factories making a specialty of packing peas, is used a *pea hulling machine* which will hull from 500 to 1,000 bushels of peas in a day without bruising or crushing the peas. Other special machinery is a *pea cleaner* which is a slowly revolving screen cylinder that removes pieces of pods and other coarse particles, and a *pea separator* which is a revolving perforated cylinder that grades the peas into various sizes. A hulling machine costs about $1,500, and the separator costs about $300. The *Automatic Pea Filler and Briner* is another valuable piece of machinery in the pea factory. It may be set to fill the cans with an exact amount of peas, and a hot brine of a definite quantity is automatically poured into each can.

Another machine that greatly aids in increasing capacity in a factory is the Hawkins capping machine. There have been capping machines in use for more than ten years, but all of them entailed considerable labor and confusion. With them it was necessary to place by hand a dozen warm cans upon a tray, by hand feed the tray to the capper and by hand take away the tray after the capping and after taking out the cans return the tray for another dozen

cans. The Hawkins machine is constructed upon a totally different plan. It uses no trays, but has a continuous supply of cans. The machine takes the cans from the filler and feeds them automatically to the wiper, a series of revolving brushes, and when wiped clean they are carried by an operator who places a tin cap upon each can. In its passage each can comes in contact with an aciding device that works automatically and without any interruption is delivered to the capper which is operated by one man, the capacity being 45,000 cans in 10 hours. Twelve cans are capped by each operation of the capper. As they leave the capper by the continuous carrier another operator tips the cans in the passage. The saving of labor and expense by this machine is very great, and factories which are large enough to use it find that it greatly cheapens the cost of packing.

Outfit for a tomato canning plant, 40,000 cans capacity per day.

2 60-H. P. boiler, complete with all trimmings.
1 25-H. P. engine, complete with all trimmings.
1 100-bbl. cyprus water supply tank.
1 4-ton wagon scale.
1 Power washer and scalder.
5,000 Brass peeling checks.
32 Dozen peeling knives.
40 Dozen 14 quart buckets.
1 Platform conveyer peeling table for 150 peelers.
1 Lockwood gang can filler.
1 Continuous chain steam exhauster.
1 Hawkins capping machine, complete with wiping machine, acid machine, counter shaft, inside heated tipping iron and automatic can counter.
1 Continuous can tester.
2 Fire pots.
2 Hand capping steels.
1 Dozen can tongs.
11 Open process kettles, 40x42 inches.
11 Perforated steam coils for kettles.
40 Process crates for 3 layers of cans.
1 Power crane.
1 Conveyer cooling tank.
8 Floor trucks.
1 3-bbl. gas machine with blower.
1 Combination vise.
1 Machine hammer.
1 Pipe wrench.
1 Cyclone pulp machine.

The estimated price of this excellent outfit is $5,500 and while it

is selected with reference to tomatoes, the addition of a few small pieces would complete the outfit for canning fruits and pumpkins.

A similar outfit for canning corn with a capacity of 40,000 cans per day, including the best modern machinery is estimated to cost $8,500.

THE VARIETY OF FOODS PUT UP IN CANS.

The variety of foods that is put up in cans and jars is exceedingly great and has not yet reached its limit. It is estimated that about 400 varieties of fruits, vegetables and meats are successfully packed in their season, and over 4,000 "brands" of these have been registered in the United States. The inferior qualities which in former years held canned goods under suspicion are now seldom met with; a better grade of raw materials is used and more care and cleanliness in canning is exercised. Reports of poisoning from the use of foods from tin cans are much less frequent. However, the cases of alleged poisoning by canned goods have never been reported over the signature of a reputable physician. It is a well known fact in most households that when a can is opened its contents must be removed from the tin at once or under the influence of the air an action will take place and render the food unfit for use. The neglect of this precaution, especially with tomatoes and similar acid foods, has caused cases of sickness.

PROCESSING.

The most particular work in canning foods successfully is what is known in the factory as the "process," and for which a responsible man known as the processor is an absolute necessity. He was once supposed to have locked up in him great secrets without which canning could not be properly done. His importance, however, is not diminished in the slightest degree by the disclosure of the principles of his processes, for his peculiar and "mysterious" power rests in his experience and good judgment in performing his particular work. Processing simply means the cooking of the canned goods at such a degree of temperature and for such a length of time that the contents of the can will be effectually sterilized and cooked tender. The length of time required varies with the article being canned and the temperature under which the boiling takes place. Two kinds of processing kettles are used; the *open top* and the *closed top* kettles. In the former, boiling takes place at 212° F. and no higher temperature can be secured. This is known as the *open bath pro-*

cess. The closed top kettle is an iron chest or retort into which steam may be introduced under pressure, and thus raise the temperature of the boiling water above the normal boiling point. After the filled cans are placed in this kettle, it is run full of water to the upper blow-off pipe, and the lid is then bolted securely. As steam is being introduced the upper blow-off pipe is left partially open until the water boils or the thermometer registers 212° F. The blow-off pipe is then closed tightly and the safety valve set to a temperature of 240° F. The higher the degree of heat carried the shorter is the time necessary for processing.

The following list of products and the necessary temperature with the required time in a closed-top process kettle is given by Duckwall in "Bacteriology:"

Corn, 250 degrees Fahrenheit, 55 minutes.

Young peas, 240 degrees Fahrenheit, 15 minutes.

Marrowfats, 240 degrees Fahrenheit, 25 minutes.

Milk, 250 degrees Fahrenheit, 50 minutes.

Products containing milk, 250 degrees Fahrenheit, 50 minutes.

Meats, 250 degrees Fahrenheit, 55 minutes.

Meat soups, 250 degrees Fahrenheit, 50 minutes.

Peaches, 240 degrees Fahrenheit, no time given.

Cherries, 240 degrees Fahrenheit, 2 minutes.

Plums, 240 degrees Fahrenheit, 2 minutes.

Pears, 240 degrees Fahrenheit, 12 minutes.

Tomatoes, 240 degrees Fahrenheit, 10 minutes, hot; cold pack, 15 minutes.

Apples, 240 degrees Fahrenheit, 2 minutes.

Berries, 240 degrees Fahrenheit, 2 minutes.

Lima beans, 240 degrees Fahrenheit, 25 minutes.

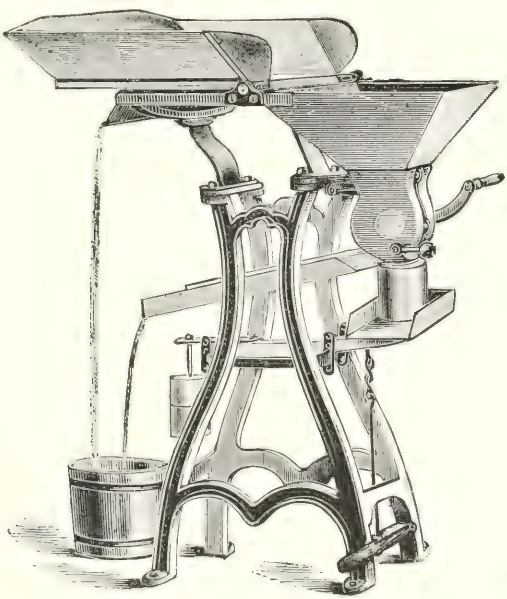
Pineapple, 240 degrees Fahrenheit, 8 minutes.

Some of these products like corn, peas, beans and the meats cannot be processed in open kettles, but the fruits and tomatoes may be. The time required would be from three to six times as long. Perfect sterilization means the killing of all bacteria that may have entered the can before it was hermetically sealed. These bacteria, numerous in variety, microscopical in dimensions and every where present, are the organisms which cause all the "swells" and "spoilage" of packed foods. Many of them are killed in a temperature of 212 degrees Fahrenheit, but those which work mischief in corn and animal products escape death in a boiling temperature and therefore are subjected to 250 degrees Fahrenheit to be overcome. Frequent heavy losses due to imperfect sterilization have induced some canners to use preservatives. This practice has met with just criticism and it is certain that the pure food

laws and the official inspections will drive all goods thus preserved from the markets. There is no reason for using preservatives in canned goods for it has been fully demonstrated that with the proper temperature and time in processing, canned products may be made to keep perfectly.

CANS.

Canned goods are put up in glass and tin. The former makes the better appearance, but is much more expensive and therefore can be employed only for a special grade of stock. Tin cans when properly sealed are just as serviceable to preserve the foods as is the glass. In the early days of the canning business when the cans were made entirely by hand, and 100 cans per day was the output of a single workman, they cost the packer about ten cents each. This price to-day would be enormous when we remember that the cost of the food in the can, together with the expense of putting it there is commonly but one-fifth the cost of the can.



MERRILL-SOULE TOMATO FILLER.

By the introduction of labor saving machinery within the last thirty years, the cost of cans has been greatly reduced and many factories make their own cans at about the same price they would have to pay for them to purchase from the can making establishments. These latter concerns are fully equipped and turn out several hundred thousand cans per day at one factory. Their prices of

cans are quoted below. The entire outfit for making cans of 2-lb. and 3-lb. sizes costs about $400. This cost would be less for a factory that is equipped with heating apparatus. With such an outfit it is possible to turn out between 3,000 and 4,000 cans per day. The list of tools required includes the following:

1 Foot press.
1 Pendulum press.
1 Pair 3 pound top dies.
1 Pair 3 pound cap dies.
1 Pair 2 pound top dies.
1 Pair 2 pound cap dies.
1 Cap header.
1 Pair square shears.
1 Pair bench shears.
2 Pairs hand shears.
1 Pair forming rollers.
4 Solder frames and cylinders, 3 pounds.
4 Solder frames and cylinders, 2 pounds.
1 Fire pot for seaming.
3 Floating machines.
1 Vise.
1 Anvil.
1 Hammer.

Tin plate is put up in boxes, each box containing enough tin to make 270 3 pound cans or 370 2 pound cans. The price of tin plate fluctuates. The prices quoted for the last season were as follows:

PRICES OF TIN PLATES USED BY CANNERS.

I. C. 14x20 charcoal alloway, ...	
I. C. 14x20 102 pound Bessemer steel, ...	$6.15
I. C. 14x20 100 pound Bessemer steel, ...	6.00
I. C. 13½x19½ 95 pound Bessemer steel, ...	5.95
I. C. 13½x19½ 90 pound Bessemer steel, ...	5.90
I. C. 14x22 110 pound Bessemer steel, ...	6.75
I. C. 14x22 100 pound Bessemer steel, ...	6.50

Cans are made in certain sizes and shapes.

No. 1 is a 1 pound can 2¾ inches in diameter and 4 inches in height.

No. 2 is a 2 pound can 3 7-16 inches in diameter and 4 9-16 inches in height.

No. 3 is a 3 pound can 4 3-16 inches in diameter and 4⅞ inches in height.

"Jersey" is a 3 pound can 4¼ inches in diameter and 5 inches in height.

No. 6 is a 6 pound can, double capacity of No. 3.

No. 10 is a 1 gallon can 6½ inches in diameter and 7 inches in height.

Lunch cans are made usually in two sizes:

No. 1 lunch can has same diameter and half the height of standard No. 2.

No. 2 lunch can has same diameter and half the height of standard No. 3.

The abreviations S. H. and L. H. in quotations of cans means small hole and large hole openings at the top.

PRICES OF CANS IN 1902 FOR MARCH DELIVERY.

No. 1 cans 1½ inch opening,	$11.00 per 1,000
No. 2 cans 1½ inch opening,	15.00
No. 3 cans 2 1-16 inch opening,	20.00
Gallons 2 1-16 inch opening,	45.00
No. 1 tall 1½ inch opening,	12.00
No. 2 tall 1½ inch opening,	16.00
No. 1 lunch 1½ inch opening,	12.50
No. 2 lunch 1½ inch opening,	17.50
No. 1 oval 1½ inch opening,	13.50
No. 2 oval 1½ inch opening,	18.50
No. 3 Jersey (4¼x5 inches) 2 1-16 inches,	21.00
No. 3 Jersey (4¼x5¼ inches) 2 1-16 inches,	22.00
No. 3 Jersey (4¼x5½ inches) 2 1-16 inches,	23.00
No. 3 Jersey (4¼x5¾ inches) 2 1-16 inches,	24.00

For each increase in size opening, 50 cent per thousand additional. Less than car load lots, $1.00 per thousand additional.

These prices are subject to change at any time.

SOLDER-HEMMED CAPS.

1½ inch size,	$0.95 per 1,000
2 1-16 inch size,	1 30
2 7-16 inch size,	1.70

Factories wishing to keep their employes at work through the winter months find it advantageous to secure a can making outfit and make their supply of cans in the winter. Where this is not an object, it is customary to buy the cans which are shipped in boxes containing two dozen cans. These boxes are the cases in which the canned goods are placed upon the market.

LABELING.

Much care is exercised in the choice of labels for canned goods. The grocers shelves and window display of such goods present an attractive appearance when tastefully arranged. The colored labels aid greatly in selling such goods. The price varies from $1.00 to $3.00 per thousand.

The labeling of cans is deferred until the rush of packing is over except for orders of prompt delivery. The labels are usually put on by hand in factories with a capacity under 10,000 cans per day. The prices paid for this work is 25 cents per 1,000 cans. In the larger factories, machines for labeling and for boxing are used.

CONTRACTS BETWEEN GROWERS AND CANNERS.

It is customary for canners to furnish the farmers, who contract to grow certain crops for them, with the seeds or even plants for such crops. These are supplied in sufficient quantities and free of cost. The purpose of this is to insure a uniform and desirable quality in the tomatoes, corn or whatever crop it may be. A written contract is always necessary to insure a sufficient tonnage to keep the factory in operation during the ripening season. It is fairer to contract to deliver the yield of a certain number of acres than a definite number of tons, for the yield is always variable, but the number of acres may be a fixed quantity. A very brief and simple form of contract generally used with the tomato growers of New Jersey is as follows:

FORM OF NEW JERSEY CONTRACT.

This is to certify that we......................., have bought of .... the product of .... acres of tomatoes for the season of .... at $.......... per ton, delivered at our cannery ....

Stock to be in first class merchantable condition. To be planted about .... 190 .

Signature, ...

Signature, ...

Other stipulations are sometimes inserted, limiting the time of delivery of stock, defining refusable material, and to protect the cannery in case of fire, accident or other contingency.

Following is a fuller form of contract:

TOMATO GROWERS CONTRACT.

.... Pa., ...190..

No. ......

I .... hereby agree to fur-

nish the land and everything necessary to plant and cultivate in proper manner .... acres of land in tomatoes, all to be planted with the variety of seeds furnished by the ....Canning Co.; and I agree to deliver all the products of the above acreage to the.................. Canning Co. at their factory in............. Pa., in a sound and ripe condition; I also agree to forfeit $5 per acre for any shortage in the cultivated area under the contracted figure. The................ Canning Co., agrees to pay me $25.00 per acre for all the tomatoes they fail to receive.

In consideration of the compliance with the above conditions the ....Canning Co., agrees to furnish all the seed necessary free of charge, and to pay for the tomatoes $........ per ton (of 2,000 pounds) delivered at the factory as above agreed. Settlement to be made on the........................

Tomatoes to be delivered between the hours of 7 a. m. and 6. p. m., on each working day of the week, except Saturday.

I hereby agree that in the case of the destruction of the cannery by fire, or the elements, or if for any unavoidable cause the factory is unable to receive all tomatoes grown, said factory shall have the right to limit the delivery of said acres.

.... Grower.

.... Canning Co.

THE SALE OF CANNED GOODS.

The sale of canned goods of all kinds is made principally through agencies known as canned goods brokers. Some small canners have disposed of their stock directly to the grocerymen of a neighboring city, and others, packing a single line of goods, have contracted with larger factories to deliver to them the entire pack of a season as soon as it is ready to ship. Such sales of goods are with or without labels. In the latter case the "country packer" has no brand and it is likely he will lose pride in his output. The factory receiving such goods places its own labels upon the cans and in consequence the consumers discover that certain brands are no guarantee of the quality of goods bearing them. This is one of the objectionable practices of the canning business.

As has been said the great bulk of canned goods is sold through brokers, upon written contracts between the canner and the broker. Such contracts may be made early in the season for "futures," that is for a certain number of cases of a particular brand of goods at an agreed price per case, to be delivered at a certain date. Goods sold under contract for immediate delivery are called "spots." Packers are usually required to guarantee their goods six months against

"swells." It does not matter whether the goods lies in the wholesale warehouse or in the store of the retailer, all spoilage occurring within six months from date of shipment, is redeemed by the packer. Contracts are made in triplicate, one for the packer, one for the buyer, and the third for the broker. A sample form of contract for futures is furnished by Messrs. Baker & Morgan, brokers, Aberdeen, Md.

FORM OF CONTRACT FOR FUTURES.

No. 932.

Aberdeen, Feb. 7th, 1902.

Sold to Mr. James Smith,

Cincinnati, Ohio.

For account of Mr. C. Jones.

One thousand (1,000) c-s No. 3 standard tomatoes, pack of 1902, ... brand, at ....per doz. cash less $1\frac{1}{2}$ per cent. f. o. b. for prompt shipment when packed.

Six months guarantee against swells.

.... Brokers.

A form in use in Philadelphia is as follows:

No. 116 So. Front St.

Philadelphia, ...190

Sold ....

We guarantee to furnish promptly as possible well filled cans with fruit carefully selected.

Quality to equal previous season's pack or no sale.

Plain labels put on free—Wrapper labels, $2\frac{1}{2}$ cents per dozen extra.

When buyer's labels are desired, notice must be given at time of purchase.

Sellers not held responsible for non-delivery if caused by destruction of factory.

In case of partial failure of the crop, sellers to be only held responsible for delivery of 60 per cent. of sale made and for any portion of remaining 40 per cent. not delivered, to pay not exceeding 10 per cent. on contract price.

TERMS—Note payable
days from date of shipment, or
Cash in 7 days.

CARTAGE—2 cents per case.

To be packed of..................
and shipped as early as possible.

Swells guaranteed to Juy 1st, following date of shipment.

Signed, ...

VEGETABLES COMMONLY CANNED.

The vegetables which take the lead in canned goods are corn, peas and tomatoes, the last named being the simplest to put up successfully. It will therefore be considered here first.

TOMATOES.

It is estimated that an area of nearly 400,000 acres of good land is devoted to the growing of tomatoes for the canning factory in this country. The large pack of 1899 reported to have exceeded 7,000,000 cases of two dozen cans, indicates the importance of the tomato in the canning industry. The bulk of the crop is grown in a few States of which Maryland is in the lead. The tomato is adapted to a great extent of territory and new regions are rapidly being devoted to the tomato and its canning.

The varieties best suited to the canner's purposes are such as produce large, smooth, solid fruits. They should be such as ripen to the stem. The "Jersey Red," so commonly seen upon labels of canned goods, is not a variety of the seedmen's catalogue, but a local name in New Jersey, for a tomato that has been grown for the cannery so long that its true name has been lost. Paragon, Champion, The Stone and Perfection are all very good varieties.

The plants are easily grown from the seed by remembering that they are very tender and should have a seed bed sheltered from cold winds and much well decayed manure worked into the soil to make it loose and warm. The plants should be ready for the field not later than the middle of June, therefore, whenever late frosts would prohibit the development of a strong plant by that time in the open ground, it is necessary to start the seedlings in a hot bed. No effort is made to have the fruit for the cannery at an early date. In this latitude the fields planted for this purpose begin to ripen in August and yield heavily until frost overtakes them. The tomato varies greatly in its yield according to the variety, the treatment, and the character of the soil. Twenty tons per acre are frequently obtained, but the average yield for a term of years on fairly good soil is eight tons, for which the farmer may expect a contract price of $5 to $7 per ton. The form of contract is very brief, simply setting forth that the

product of a given number of acres of tomatoes has been purchased by a certain cannery at a stated price per ton delivered at the factory.

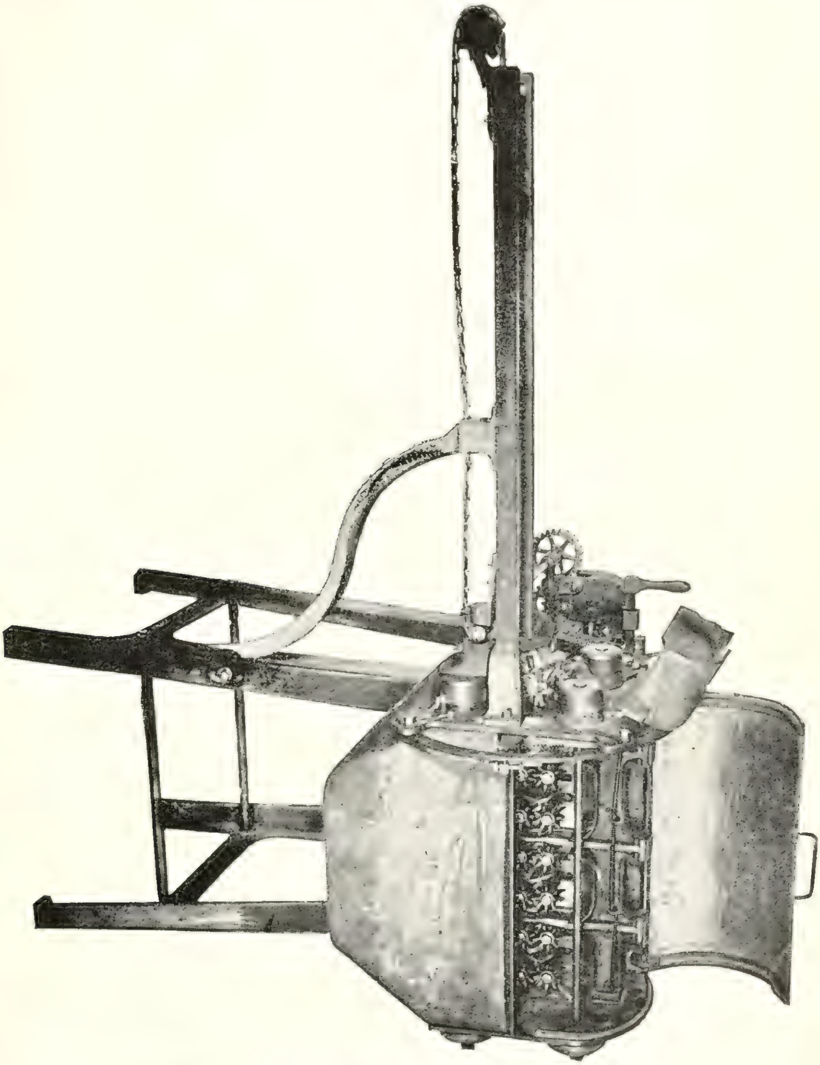
Many factories can no other product than tomatoes, and nearly every factory includes this vegetable in its list of packed goods. The tomatoes are put up in two pound and three pound cans at a cost of about 45 cents and 60 cents per dozen respectively. The practice in canning the tomato varies slightly in method. Some packers do not exhaust the cans before tipping, but cap and tip the cans as soon as they are filled and then subject them to the process. Others prefer to exhaust before the vent is tipped, and still others will steam the filled cans in steam boxes before capping them. Where the product can be rapidly passed from the scalding to the process, the first method is claimed to retain the best flavor of the tomato, but if it passes slowly from step to step the tomatoes have time to deteriorate and an inferior quality results.

The treatment of tomatoes at the factory has been given elsewhere, but is briefly outlined here again. The fruit fresh from the vines is scalded by being dipped into boiling water kept "jumping" by the injection of steam. This does not cook the tomato, but simply scalds the skin and tissue immediately under it so that the skin can be easily peeled off. This peeling is done by hand, and women are usually employed for the work. They are paid two cents per 14 quart bucketful, receiving a brass check for each bucketful as it is delivered to the packer. The checks are redeemed with cash at the office of the factory. The packer fills the cans (2 pounds or 3 pounds) as solid as possible, after which if there is to be no exhaust the cans are wiped, capped and tipped and then tested for imperfectly sealed cans by submerging about one-half inch under boiling water. This treatment promptly reveals any imperfection in the sealing of the cans by forcing out the air that rises in bubbles through the overlying water. Such cans are picked out with the can tongs and their defects are removed. The batch of cans is then processed in the open bath thirty minutes for 3 pound cans and twenty-two minutes for 2 pound cans, or in the closed bath fifteen minutes for 3 pound cans and ten minutes for 2 pound cans.

The cost of canning tomatoes like the cost of canning any other product, in fact, depends wholly upon the prices paid for raw materials and labor and the mechanical devices used. When every detail has been properly arranged the cost of packing 2 pound cans will be about forty-five cents per dozen and 3 pound cans sixty cents per dozen.

Artificial Coloring.—The market demands a very red tomato and the packer striving to meet this demand is in some sections tempted to use coloring materials. This of course is contrary to the Pure Food Laws and the conscientious packer will not transgress the law.

It is very likely that materials used to color the juice and flesh of the tomato would also color the seed, and its presence could, therefore, be easily recognized; but it is claimed by the manufacturers for the "Perfection" tomato coloring that it will not color the seeds

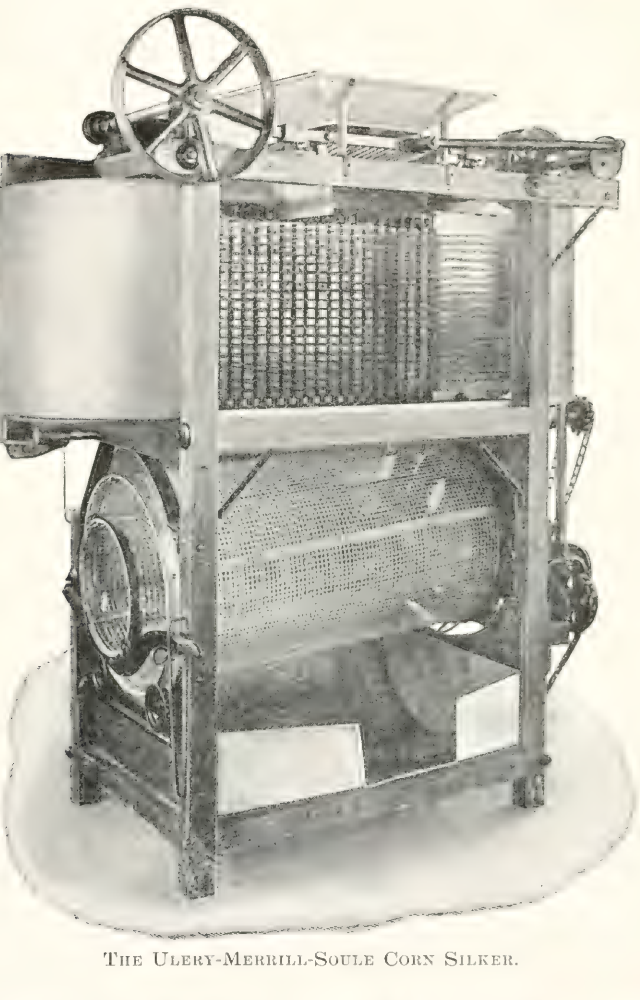


THE SPRAGUE CORN CUTTER. MODEL M. 1900 STYLE C.

when used according to directions and the colored goods would pass inspection. This coloring liquid is advertised at $2.00 per gallon, a gallon being sufficient to color 25,000 3 pound cans, and is claimed to be absolutely not prejudicial to health in any quantity that might be used.

CORN.

The canning of sugar corn is about of equal importance with that of tomatoes though the profits of packing are not so easily realized in the former by the small factory. So much special machinery for putting up corn has been invented that no factory can afford to pack corn without it.



THE ULERY-MERRILL-SOULE CORN SILKER.

The varieties of corn grown for canning are the Stowell's Evergreen and Egyptian. For a fancy grade of goods the Country Gentleman is preferred. It has small grains, white color and is sweeter than the other varieties named. The canning season is lengthened by having the seed planted at various dates in the spring at intervals of

one week from May 1 to June 15. Contracts with the farmers may stipulate the date of planting to regulate the supply of the crop. Good corn land well prepared and fertilized is used for this crop. The yield of ears in the husk as delivered to the cannery is from three to five tons per acre, for which the canners pays $4.50 to $7.00 per ton. The lower prices prevail in the west and the higher prices in the east. The margin of profit to the farmer on the raw material is as small as it is to the packer on the packed goods.

The canner prefers to have the corn in a young stage, just about when it is in the best condition for table use. He directs that the ears should be pulled early in the morning and delivered promptly at the factory. To have a good white product in the can, every detail in handling the raw material must be carefully managed.

The contract with the farmer usually provides that the corn will be delivered at the factory according to the directions of the packer, that corn too young or too old may be refused, and that it must be delivered same day as it is pulled. Canners do not like to carry corn over night, hence insist upon an early delivery each day.

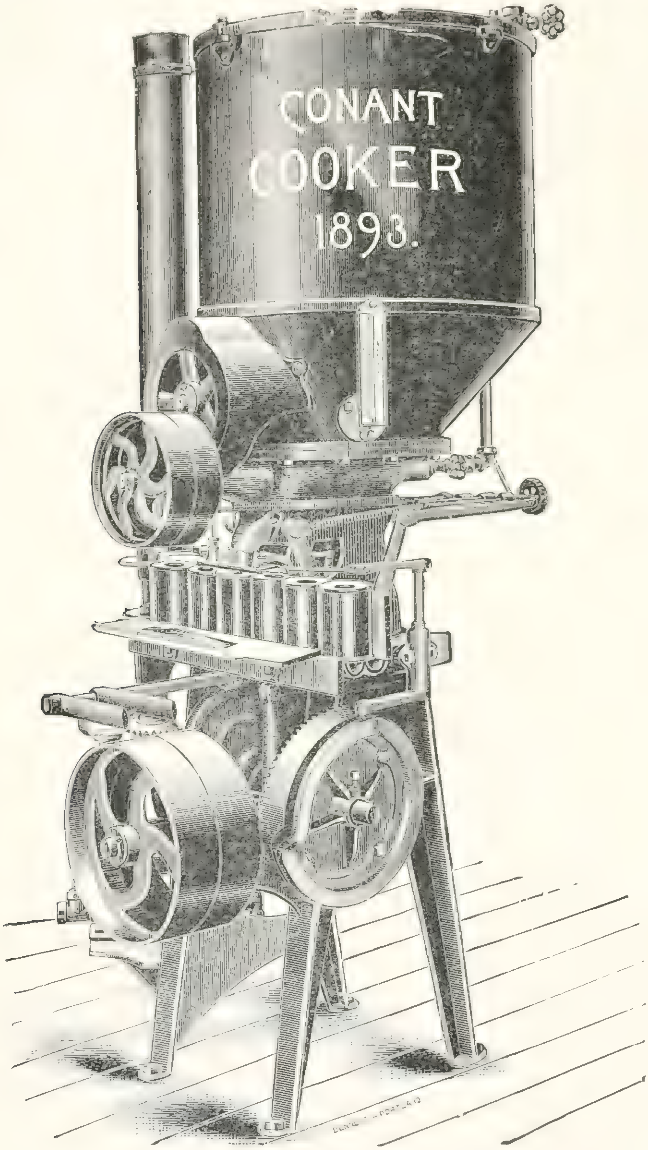
As soon as the corn arrives at the factory it is husked and the imperfect ears are trimmed of their imperfections and then passed with the good ears to the cutting machines. The Sprague corn cutter is in common use in large factories. It has a capacity of 15,000 cans per day.

Corn is cut from the cob in two different ways, by the same machinery according to the adjustment of the knives. In one case the kernels are cut off as nearly whole as possible. The corn is then passed through the silker to remove the silk and then filled cold into the cans. A weak brine is also added and the cans are then wiped and capped but not tipped. The cans are then exhausted by being immersed in boiling water for ten minutes to heat the corn and drive out the air. They are then tipped and put through the cooking process which takes place in the retorts at a temperature of 250 degrees Fahrenheit. The time of this process varies with different packers, being from forty to fifty-five minutes. After this process the cans are passed through a cold water bath to stop the cooking within, and to prevent the corn turning dark. This method is known as the moist pack or cold pack, generally practiced in Maryland.

The other method of canning corn is called the dry pack or hot pack and is commonly practiced in Maine and New York. In fact it is generally being adopted in preference to the other method in all the new corn canning sections. "Dry pack" corn commands a higher price than the "moist pack" corn.

The knives of the corn cutter are set to cut off only the upper half of the kernels while the rest is removed by the scrapers in the con-

dition of pulp. After passing the corn through a silker it is conveyed to the "corn cooker" to be heated (not to be cooked strictly speaking, for this process takes place in the retorts later), and thor-

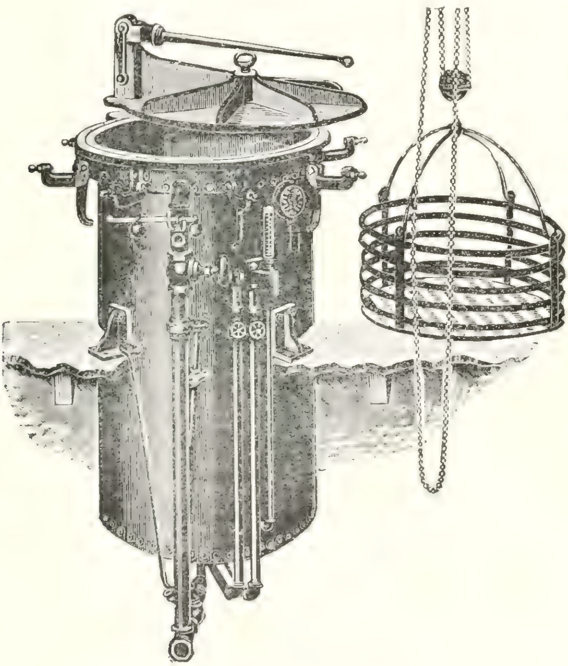


THE CONANT SINGLE CORN COOKER.

oughly mixed with the brine or syrup. This cooker fills the heated corn directly into cans, and these are then promptly capped, tipped and subjected to the sterilizing process as described for the other system of packing.

Corn is regularly packed in 2 pound cans at an average cost of sixty cents per dozen.

The margin on corn is very small and severe losses are sustained by "swells" and "sour corn." The canner must make good to the merchant all the spoilage that appears in the warehouse or the grocery store. "Swells" are the cans which bulge out the lid of the can owing to a pressure from within occasioned by a fermentation of the corn. Such corn is usually "sour" and is unfit for use. It is evident that the cooking process did not effectually sterilize the contents of the can. Some bacteria resist very high temperature,



West Process Kettle.

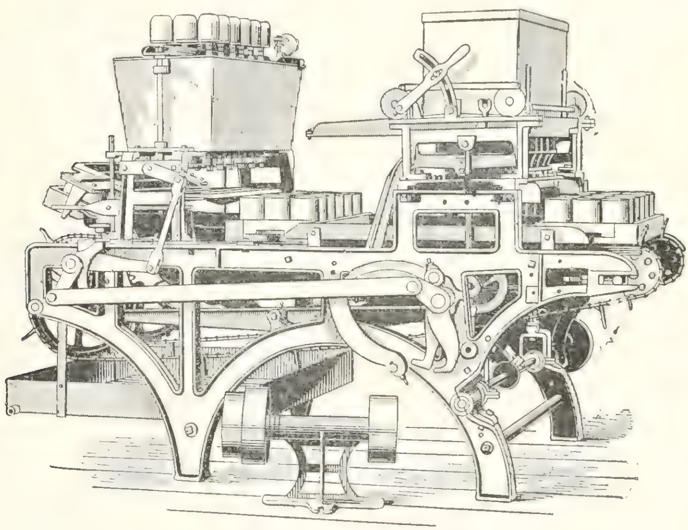
and the packer has learned by experience that the excessive cooking of high temperature turns his corn dark. Therefore the demand for whiteness and the fear of spoils keeps the packer anxiously awaiting the results of his labor.

Heat travels slowly through a mass of corn in the can and since the sterilization is often imperfect, the processor keeps himself informed of the exact temperature in the corn at the very centre of the can by using an appropriate thermometer, made expressly for the purpose. Several styles of such thermometers are in use, a very good one is the A. B. H. self-registering sterilizing thermometer, which is firmly suspended from the top of a can made expressly for the test. The bulb of the thermometer is in the exact centre of the

can. The can is filled with corn and introduced with a batch of cans in the processing retort; at the conclusion of the process the test can is removed, the thermometer taken out and the registered temperature is easily read. The test can is then emptied and cleaned for the next batch of corn to go into the retort.

PEAS.

The pea canning business has been greatly modified in recent years by the invention of some remarkable machinery, particularly the Chisholm-Scott Pea Viner. Formerly a great army of pickers was necessary in pea canning sections to pick the peas from the vines in the fields. Another army of hands was necessary to hull the green



THE BALLARD PEA FILLING AND BRINING MACHINE.

peas and so throughout the whole series of operations of canning peas the hand labor was excessive, tedious and expensive. Now the vines are cut with the scythe or mower, hauled to the factory and delivered to the viner or huller which shells and separates the peas from the vines, discharging the latter to one side and the former to the cleaner. The patentees and manufacturers of this viner are the Chisholm-Scott Co., Suspension Bridge, N. Y. They do not sell the machine, but place them with canners upon a royalty basis in restricted territories.

The varieties of peas most generally planted for canning are Alaska, Blue Beauty and French Canner. The first two varieties are known

to the canner as the "Early June" peas. They are planted as early in the spring as the weather will permit. The peas may be planted in drills to permit surface cultivation or sown broadcast. The latter method, however, is successful only with certain rich soils and the dwarf varieties of peas. The quantity of seeds required to plant an acre by the drill method is about 2½ bushels and by the broad cast method from 3 to 4 bushels.

The vines are cut when they are yet green, before the oldest pods have begun to shrivel and delivered at the factory. The grower is entitled to the pea vines after the hulling. The pea being a leguminous plant a "nitrogen gatherer," the refuse tops are a valuable fertilizer, and if plowed under or composted with the manure heap they are worth many times over the cost of taking them home.

It has been said the peas that are taken from the vines by the remarkable machinery called the Viner, then cleaned by passing through the cleaner, then graded into four or five sizes for the cans, must show a uniform size of peas to pass as properly packed goods. The smaller sizes command the best prices. The peas are then "blanched" by scalding them in wire or perforated iron baskets. This treatment cleans and heats the peas through, after which they are delivered to a machine that fills the cans with peas and brine ready for capping. After effectually sealing the cans they are processed in the closed kettle at 240 degrees Fahrenheit for fifteen to twenty-five minutes according to the condition of the peas whether young or old. After the cans are cooled they are ready for the packing house where labeling and casing is done.

Peas are put up in 2 pound cans at a cost of about seventy cents per dozen.

BEANS, STRING.

A large quantity of string beans are canned by factories fitted up for packing peas and corn. The varieties chiefly planted are Early Valentine, Early Mohawk and Black Wax. The yield varies greatly, but for fair land with good cultivation it may be estimated at 100 bushels per acre, for which the canner will pay about thirty cents per bushel. String beans are prepared for the can much as peas are, the ends and "strings" are removed and the large pods broken in two. The product is then blanched as described for peas, packed in 2 pound cans, filled with hot brine, capped and tipped. Processing takes place in the closed kettle at a temperature of 240 degrees Fahrenheit for forty minutes.

BEANS, LIMA.

The Large White Lima and the Small White Lima are the two principal varieties of lima beans that are packed. The yield is about 75 bushels of shelled beans to the acre. The pods are shelled by hand and the beans are packed, without blanching, in 2 pound cans, dipped in a hot brine and sealed in the usual way. Lima beans are processed in the closed kettle for thirty minutes at 240 degrees Fahrenheit.

SUCCOTASH.

A combination of sweet corn and small lima beans is much called for in certain markets and will generally be found among "quotations." The proportion of each is about two parts of the former to one part of the latter. The corn is cut from the ear as for the "moist pack," that is cutting off the whole grain. The combination is then put in 2 pound cans according to the "moist pack" method for corn.

SQUASH AND PUMPKIN.

Boston Marrow and Hubbard squash, and any good cooking variety of pumpkin are canned in limited quantities, the latter for making pies.

Squash and pumpkins are first blanched, just enough to soften the rind to make peeling easy. They are then sliced and grated or mashed and packed into 3 pound cans making them full and using no liquor. The processing may be done in either the open or closed kettle, allowing forty minutes in the former and fifteen minutes in the latter.

FRUITS.

The process of fruit canning is very simple and therefore fruits are excellent material for a canner to begin on. The principles on which commercial canning is based are the same as those by which fruits have been canned for many years in kitchens. But in the handling of large quantities of perishable fruit in the manner that becomes necessary at a large canning factory, a considerable executive ability is demanded. The purchase of the fruit to be delivered in regular installments, the prompt preparation of it for the cans to avoid discoloration and deterioration, and every other operation to the conclusion of the process require some experience, wisdom and

good judgment. The canning of fruit is upon very narrow margins of profit and therefore the success of a business depends greatly upon careful management, so that every laborer will be constantly employed, every operation successfully performed and that every expense is reduced to a minimum figure. Fruit canning is most extensively carried on in California where the opportunities for getting large quantities and fine qualities of fruit cannot be excelled. For forty-five years this industry has made rapid growth in California, and the eastern canners are meeting serious competition with the high grade California canned fruits in the eastern markets.

California fruits are put up with greater care and selection than is practiced in the east. They are packed in four distinct grades. The *first grade* is of the choicest fruits, free from all defects, peeled by hand and carefully packed in cans using a strong syrup. These are known in the markets as EXTRAS, being put up in 3 pound and 2½ pound cans. The *second grade* is known as EXTRA STANDARDS, being selected and handled with the same care as for the first grade. The fruits of the second grade are slightly smaller than in the *extras*, and are always put in 2½ pound cans. The *third grade* is known as STANDARDS. In this the size of the fruit is smaller than in the preceding and the paring (when necessary), is done by machine. The *fourth grade* is known as SECONDS. In this an inferior grade of fruit is used. The syrup used in these four grades varies from a 10 per cent. solution in the fourth grade to a 32 per cent. solution in the extras.

All kinds of fruit may be canned successfully. Brief directions are given only for the fruits which are commonly packed in the eastern States.

APPLES.

Many small canning factories have been started in localities where apples are extensively grown, and have found it profitable to put up this one line of goods only. There are many old orchards bearing quantities of fruit that makes excellent canning material, but not being of the well known market varieties, do not command good prices when barreled. For this fruit the canner pays from 25 cents to 50 cents per bushel at the factory and the farmers are willing to sell at such prices.

Any variety that is a good cooking apple is acceptable for canning. The season may begin in August with the Red Astrachan, and this followed with Jeffries, Duchess of Oldenburg, Maiden's Blush, St. Lawrence, King, Baldwin, Bellflower, Northern Spy, Rhode Island Greening, etc.

At the factory the apples are pared and cored by suitable machines run by hand or steam power. They are then packed as solid as possible into 3 pound cans or in gallon cans, as the market demands. The cans are then filled with cold or hot water; if the former, the cans are exhausted 5 minutes at 212 degrees Fahrenheit before tipping, if the latter, they are tipped at once and submitted to the process. If this is done in the open bath the boiling is continued 10 minutes at 212 degrees Fahrenheit, if in the closed bath 2 minutes are allowed for the process at 240 degrees Fahrenheit.

PEACHES.

Peaches are successfully grown in several sections of Pennsylvania and it is remarkable that there are not more factories in these sections to work up that fruit which cannot find a better market. Peach canning is one of the important branches of the industry and a good quality of goods will find a ready sale. The best varieties are those with a firm, yellow flesh, like the Late Crawford, Elberta and Smock. The canner pays from fifty cents to $2.00 per bushel according to the season and quality of the fruit. At the factory the fruit is pared, cut into halves, removing the stones. The pieces of peach are then carefully packed into the cans and the ten degree cane sugar syrup is poured over them to fill the cans. They are then capped, exhausted five minutes at 212 degrees Fahrenheit, tipped and processed ten minutes at 212 degrees Fahrenheit in open bath or two minutes at 240 degrees Fahrenheit in closed bath.

It costs from $1.50 to $2.50 per case to put up such peaches, and they sell in the market at usually double the cost.

"Pie Fruit" is an inferior grade of peach not pared but cut into pieces and put up in the cans with water instead of a syrup. They cost less to pack and are of course sold at a lower figure than the other grades of peaches.

PEARS.

Pears in cans are always in good demand. The supply of the fruit is limited. The Bartlett stands at the head of the list of varieties, although it is not necessary to refuse any variety at the canning factory. The best price is paid for Bartletts ranging from forty cents to $1.25 per bushel. Pears are put up in 2 pound cans in the east and in 3 pound cans in California. The fruit is pared, cut into halves or quarters, removing the core and bruises and put up in a cold cane-

sugar syrup using a ten per cent. or even heavier solution. The cans are exhausted at 212 degrees Fahrenheit for five minutes then processed twelve minutes in the open bath or twelve minutes in the closed bath at 210 degrees Fahrenheit. The cost of putting up such pears ranges from $1.00 to $2.00 per case.

Other fruits that are canned with profit by the factories located within reach of the products are cherries, plums, quinces, apricots, blackberries, currants, gooseberries, grapes, pineapples, raspberries, strawberries and huckleberries.

APRICOTS AND NECTARINES.

Apricots and nectarines are canned chiefly in California. These fruits are wiped but not pared (except for special grades of goods), cut into halves and packed into cans with a cane sugar syrup.

BERRIES.

Blackberries, currants, gooseberries, grapes and whortleberries are all packed to a limited extent. The method of canning is the same in all cases. When the fruit is cleaned it is packed in 2 pound cans with cold or hot water, sealed and processed as for apples.

Raspberries and strawberries are prepared for the cans as for other berries, but are packed with a syrup using extra heavy syrups for the strawberries. The processing is about the same as for other berries.

CHERRIES AND PLUMS.

The best cherries and plums in cans come from California, though some cherries are packed in the east. These fruits are put up with a syrup and the white or yellow-fruited varieties are preferred.

Other fruits are packed, but the principal ones of the east have been considered. The pineapple is very largely canned in Baltimore, using the fruits which are shipped north from Florida and other southern countries.

Jellies. Canners of fruits often find it convenient to convert some of their fruit into jellies, but too often the fruit reaches them too ripe to make good jelly. The fruit should be at its first stage of ripeness, carefully cleaned and cleared of decayed spots. It is then run through a grinding machine and put into a kettle with just enough water to keep the fruit from burning or scorching. It is boiled slowly for a half hour to extract the juices and then placed in jelly

sacks to drain the liquid from the pulp (ordinary sugar sacks washed clean are excellent for this purpose.) The juice is further cleared by passing through one or more layers of cotton wool. When it has been thus treated, the juice is again heated very slowly. To every gallon of juice is added four and one-half pounds of granulated sugar, and boiling is continued for twenty minutes more. The jelly glasses are then filled full and left to cool, then a teaspoonful of boiling hot paraffine wax is dropped over the jelly in each glass, and a tin cover over the glass completes the work.

Crystallized Fruit. This style of preserving fruit is peculiar to the California packers. Candied, crystallized or glaced fruits are now found among all first class confections, and were first prepared about 25 years ago. The processes are evolved from much experimentation and are not made public. This much may be said of the general method of making candied fruit. The juice of the fruit is extracted and replaced with a sugar syrup which upon hardening prevents decay and at the same time retains the natural shape of the fruit. All kinds of fruits may thus be preserved. The best fruits are selected when at the proper degree of ripeness for ordinary canning. The large fruits are pared and halved, and plums and cherries are pitted. The fruit thus prepared is placed in baskets or perforated buckets and suspended in boiling water. This removes the juice from the fruit and demands the greatest skill to be properly timed. After the fruit is cooled it is placed in earthen pans and covered with a very heavy syrup, ordinarily one testing 70 degrees by a Balling saccharometer. In this syrup, made with white granulated cane sugar, the fruit is allowed to remain for one week, then there is danger of a fermentation setting in which must be checked by heating to boiling point the fruit and syrup. This heating is repeated at intervals as necessary for about six weeks. The fruit is then taken out of the syrup, washed in clean water and is then glaced or crystallized as preferred. It is glaced by dipping into a thick sugar syrup and being left to harden quickly in the air. By dipping thus and causing it to cool and harden slowly, the sugar on the surface crystallizes and makes the crystallized fruit.

THE STANDARD OF THE BALTIMORE CANNED GOODS EXCHANGE.

Officers of the Exchange.

Wm. Miller, President. A. F. Jones, Secretary.

Apples.—Pared and cored, clear in color; cans to be full of fruit, put up in water.

Blackberries.—Cans to cut out not less than two-thirds full after draining; fruit to be sound, put up in water.

Cherries.—White Wax. Cans to be full of fruit, free of specks and decay, put up in not less than ten degrees of cold cane sugar syrup.

Cherries.—Red. Cans full of fruit, free of specks or decay, put up in water.

Gooseberries.—Cans to cut out not less than two thirds full after draining; fruit unripe and uncapped; put up in water.

Egg Plums and Green Gages.—Cans full, whole fruit, free from reddish color or specks, put up in not less than ten degrees of cold cane sugar syrup.

Peaches.—Cans full, fruit good size, evenly pared, cut in half pieces, put up in not less than ten degrees of cold cane sugar syrup.

Pie Peaches.—Cans full, fruit sound, unpared, cut in half pieces, put up in water.

Pears.—Bartlett. Cans full, fruit white and clear, pared, cut in half or quarter pieces, put up in not less than ten degrees of cold cane sugar syrup.

Pears.—Bell or Duchess. Cans full, fruit pared, cut in half or quarter pieces, put up in not less than ten degrees of cold cane sugar syrup.

Pineapples.—Cans full, fruit sound and carefully pared, slices laid in evenly, put up in not less than ten degrees of cold cane sugar syrup.

Plums and Damsons.—Cans full, sound fruit, put up in water.

Quinces.—Cans full, fruit pared and cored, cut in half or quarter pieces, put up in not less than ten degrees of cold cane sugar syrup.

Raspberries.—Cans to cut out not less than two-thirds full and after draining, fruit to be sound, put up in not less than ten degrees of cold cane sugar syrup.

Strawberries.—Cans to cut out after draining not less than half full of fruit, which shall be sound, and not of the variety known as seedlings, put up in not less than ten degrees of cold cane sugar syrup.

Whortleberries.—Cans full, fruit to be sound, put up in water.

VEGETABLES.

Lima Beans.—Cans full of green beans, clear liquor.

String Beans.—Cans full, beans young and tender and carefully strung, packed during growing season.

Corn.—Sweet corn only to be used from the cob while young and tender, cans to cut out full of corn.

Peas.—Cans full of young and tender peas, free of yellow or black eyes, clear liquor.

Pumpkin.—To be solid packed as possible, free from lumps and of good color.

Succotash.—Cans to be full of green corn and green lima beans.

Tomatoes.—Cans to be reasonably solid, of good, ripe fruit, cold packed.

Oysters.—To cut out not less than five ounces for No. 1, and ten ounces for No. 2 cans; of dry meat, after liquor is drained off. To be good size and bright color.

STANDARD SIZES FOR CANS.

Adopted by the Baltimore Canned Goods Exchange, November 19, 1893.

	Diameter.	Height.
No. 1 Cans	$2\frac{3}{4}$ in.	4 in.
No. 2 Cans	3 7-16 in.	4 9-16 in.
No. 3 Cans	4 3-16 in.	$4\frac{7}{8}$ in.
No. 6 Cans, twice the quantity of No. 3.		
No. 10 Cans	$6\frac{1}{4}$ in.	7 in.

STANDARD SIZES FOR BOXES.

Sizes of Boxes for Canned Goods—Inside Measurement.

2 dozen Cans, size 1,	$11\frac{1}{2}$x $8\frac{1}{2}$x $8\frac{1}{4}$ inches.
2 " " " 3,	$14\frac{1}{2}$x$10\frac{1}{2}$x $9\frac{1}{2}$ "
2 " " " 3,	$17\frac{1}{4}$x13 x$10\frac{1}{4}$ "
4 " " " 1,	$16\frac{1}{2}$x$11\frac{1}{4}$x $8\frac{1}{4}$ "
1 " " " 1, flat,	$11\frac{1}{2}$x $8\frac{1}{2}$x $4\frac{1}{4}$ "
1 " " " 2, "	$14\frac{1}{4}$x$10\frac{1}{2}$x $4\frac{3}{4}$ "
$\frac{1}{2}$ " Gallon Cans,	19 x$12\frac{3}{4}$x $7\frac{1}{4}$ "
1 " " " high boxes,	19 x$12\frac{3}{4}$x14 "
1 " " " flat "	$25\frac{1}{2}$x19 x 7 "
1 " No. 6 Cans,	$20\frac{3}{8}$x$15\frac{3}{8}$x $6\frac{7}{8}$ "

SHIPPING WEIGHTS FOR CANNED GOODS.

No. 1 Boxes,	26 pounds.
No. 2 Boxes,	46 "
No. 3 Boxes,	70 "

PUBLICATIONS CONCERNING THE CANNING OF VEGETABLES AND FRUITS.

The Art of Canning and Preserving as an Industry. By Dr. Jean Pacrette, of Paris. New York, 1901. Price $10.00.

The Secrets of Canning. By Ernest Schwaab. New York, 1899. Price $5.00

Bacteriology. By E. W. Duckwall. Baltimore, 1899. Price $5.00. A study of the bacteria of canned foods.

Fruit Growers Manual, for Canning Fruits, etc. By Hemlon-Meriam Co. California. Price $2.50.

Tomato Growing (for the Cannery), Farmer's Bulletin No. 76. U. S. Dept of Agr. By Edw. B. Voorhees, M. A. Director of New Jersey Agricultural Experiment Station. 1898.

Pea Canning in Delaware. Bulletin XLI. Delaware Agricultural Experiment Station, Newark, Del. By G. Harold Powell, Horticulturist of Station. 1898.

These publications have been freely consulted in the preparation of this article and while making acknowledgments to the authors, the writer also remembers the canners who extended courtesies at their factories and the canning machinery manufacturers for the valuable suggestion they have made. Special thanks are due the Sprague Canning Machinery Co., and the Ayars Machine Co., for the use of illustrations of modern special machinery.

SUPPLY HOUSES AND MANUFACTURERS OF CANNING FACTORY MACHINERY AND MATERIALS.

The American Can Co., Bowling Green Building, New York city, N. Y.; Merchant's Bank Building, Baltimore, Md.; Merchant's Loan and Trust Building, Chicago, Ill.; 209-221 Mission street, San Francisco, Cal.

The Sinclair-Scott Co., Wells and Patapsco streets, Baltimore, Md.

Cox Bros. & Co., Bridgeton, N. J.

Stevenson & Co., 229 N. Holliday street, Baltimore, Md.

Ayars Machine Co., Salem, N. J.

Consumers Can Co., Baltimore, Md.

The Fred H. Knapp Co., 42 River street, Chicago, Ill., labelling machine.

The Grasselli Chemical Co., Cleveland Ohio, soldering flux.

Thomsen Chemical Co., Baltimore, Md., soldering flux.

A. B. Robins & Co., 724 E. Pratt street, Baltimore, Md., outfits.

H. Cottingham, Baltimore, Md., outfits.

The Sprague Canning Machinery Co., Chicago, Ill., outfits.

Burt Labelling Machine Co., 404 Atlantic Trust Building, Baltimore, Md.

Remington Machine Co., Wilmington, Del.

The Monumental Label Co., Baltimore, Md.

Hastings Industrial Co., 79 Dearborn street, Chicago, Ill., outfitters.

E. J. Lewis, Middleport, N. Y., machinery.

John E. Smith's Sons, Buffalo, N. Y., kraut cutters.

Stayman & Co., 125 East Falls avenue, Baltimore, Md., can making outfits.

Thomson Manufacturing Co., 33 S. Gay street, Baltimore, Md., machinery and cans.

A. Schultz & Co., 1016 East Baltimore street, Baltimore, Md., solders and fluxes.

J. S. Hull Manufacturing Co., 125 127 East Falls avenue, Baltimore, Md., gasoline apparatus.

Moore & McFerren, Hoopestown, Ill., cottonwood boxes.

The Union Can Co., Hoopestown, Ill., tin cans; Buffalo, N. Y., tin cans.

Adriance Machine Works, 252 Van Brunt St., Brooklyn, N. Y., can making machinery.

CANNED GOODS BROKERS.

Baker & Morgan, Aberdeen, Md.

N. H. Dudley & Co., cor. Duane and Hudson streets, New York city.

Walter G. Holcombe, 303 California street, San Francisco, Cal.

M. Morfit, Baltimore, Md.

T. J. Meehan & Co., 407 Water street, Baltimore, Md.

H. H. Taylor & Sons, Baltimore, Md.

J. L. Rowland & Co., Baltimore, Md.

Wm. H. Nichols & Co., 42 River street, Chicago, Ill.

Watson M. Null, 241 S. Front street, Philadelphia, Pa.

Wm. G. Bonstedt & Co., 10 S. Front street, Philadelphia, Pa.
Wm. J. Young, 53 S. Front street, Philadelphia, Pa.
Thos. Roberts & Co., 116 S. Front street, Philadelphia, Pa.
Wilson Sherborne & Co., 107 N. Water street, Philadelphia, Pa.
Wm. Castle, 18 N. Water street, Philadelphia, Pa.

CANNING FACTORIES OF FRUITS AND VEGETABLES IN THE UNITED STATES.

California:

Campbell, J. C. Amsley Packing Co.
San Francisco, Hickmot Asparagus Canning Co.
San José, J. H. Flickinger & Co.

Colorado:

Denver, The Küner Pickle Co.
Longmont, The Empson Packing Co.

Delaware:

Bridgeville, H. P. Cannon.
Camden, Stetson & Ellison.
Harrington, Fleming & Co.
Laurel, Geo. W. Stradley.
Milford, David Reis.
Rising Sun, Farmer's Preserving Co.
Seaford, Greenabaum Bros.
Seaford, Ross Bros.
Smyrna, John H. Hoffnicker.
Woodside, S. H. Derby & Co.

Illinois:

Bloomington, Bloomington Canning Co.
Elgin, Elgin Packing Co.
Eureka, Dickinson & Co.
Hoopestown, Illinois Canning Co.

Indiana:

Cayuga, N. S. Martz.
Eaton, Indiana Packing Co.
Greenwood, J. T. Polk.
Muncie, Crampton-Tobey Canning Co.

Indiana—Continued.

Muncie, Magic Packing Co.
New Castle, Blue River Canning Co.
Sellersburg, Silver Creek Canning Co.

Iowa:

Fort Madison, Fort Madison Canning Co.
Waverly, The Kelly Canning Co.

Maine:

Brunswick, Baxter Bros. Co.
Farmington, C. S. Dingley & Co.
Jonesport, Jonesport Packing Co.
Lubec, Eureka Packing Co.
North Lubec, Lubec Packing Co.
Portland, Portland Packing Co.
Portland, The Twitchell-Chaplin Co.

Maryland:

Baltimore, W. W. Boyer & Co.
Baltimore, The John Boyle Co.
Baltimore, Gibbs Preserving Co.
Baltimore, W. Grech & Co.
Baltimore, S. M. Lawder & Sons Co.
Baltimore, H. J. McGrath & Co.
Baltimore, Thos. J. Meyer & Co.
Baltimore, Wm. Numsen & Sons.
Baltimore, The Sterling Packing Co.
Baltimore, The Martin Wagner Co.
Baltimore, Moore & Brady.
Bethlehem, R. M. Messick.
Buckeystown, The Buckeystown Packing Co.
Cambridge, Ivey L. Leonard Packing Co.
Easton, Hubbard & Bro.
Frederick, Monocacy Canning Co.
Goldsboro, Robt. Jarrell.
Greensboro, F. P. Roe & Bro.
Havre de Grace, H. A. Osborn.
Hillsboro, Stewart & Jarrell.
Perryman, John W. Bay & Co.
Ridge Summit, Emmond Bros.
Union Mills, B. F. Shriver & Co.
Westminster, B. F. Shriver & Co.
Westminster, Smith Yingling & Co.

Michigan:

Adrian, Adrian Packing Co.
Benton Harbor, Alden Canning Co.
Kalamazoo, The Dunkle Celery and Preserving Co.
Dowagiac, Dowagiac Canning Co.

New Jersey:

Bridgeton, B. S. Ayars.
Freehold, Jos. Brakeley.
Greenwich, Watson Bros & Co.
Salem, Hiles & Hilliard.
Salem, Stam & Bro.
Salem, Mrs. J. W. Lippencott.
Sharpstown, Kerrison M. Davies.
Stevens, Frederick Cooper.

New York:

Buffalo, Erie Preserving Co.
Buffalo, The United States Canning Co.
Clyde, Dwight Hemmingway.
East Rush, Genesee Valley Preserving Co.
Fairport, Howard Thomas Co.
Fredonia, Fredonia Canning and Manufacturing Co.
Geneva, Geneva Preserving Co.
Geneva, Torrey Park Preserving Co.
New York City, Romain & Co.
Rochester, Curtice Brothers.
Rome, Clinton Canning Co.
Rome, Fort Stanwix Canning Co.
Syracuse, H. C. Hemmingway & Co.
Taberg, A. V. Lane.
Verona, Empire State Canning Co.
Verona, Fred Merry.
Westernville, Mohawk Valley Canning Co.
Williamstown, J. J. & F. White.

Ohio:

Ashville, Sciota Canning Co.
Beach City, The Trescott Packing Co.
Canton, Canton Canning Co.
Circleville, C. E. Sears & Co.
Cleveland, Cleveland Canning Co.
Dayton, North Dayton Packing Co.

Ohio—Continued.

Pleasant Hill, Pleasant Hill Canning Co.
West Alexandria, Gem Canning Co.

Pennsylvania:

Delta, J. S. Whiteford.
Girard, Hamilton Bros.
Hanover, Winnebrenner & Co.
Littlestown, B. F. Shriver & Co.
McCall's Ferry, E. W. Urey & Co.
North East, The North East Preserving Co.
Philadelphia, Wm. F. Beck.
Philadelphia, Pennsylvania Packing and Provision Co.
Philadelphia, Selser Bros. Co.
Pleasant Grove, E. M. Haines.
Shamokin, Shamokin Packing Co.
Stewartstown, J. B. Gable.
Stewartstown, J. M. Jordan.
York, York Packing Co.
York, John H. Thomas.

Wisconsin:

Manitowoc, A. Landreth Co.
Manitowoc, East Wisconsin Canning Co.
Sun Prairie, Sun Prairie Canning Co.
Two Rivers, E. J. Vodra Canning Co.

BACTERIA OF THE SOIL IN THEIR RELATION TO AGRICULTURE.

BY FREDERICK D. CHESTER, *Bacteriologist, Delaware Agricultural Experiment Station*

The bacteria of the soil bear a most important relation to the nutrition of plants. If a soil be heated to a temperature sufficient to destroy its bacterial life, the growth of plants will be maintained therein only up to the point of the exhaustion of its easily soluble and assimilable plant food, at the end of which time they will die of starvation. The reason for this is that new plant food can no longer be elaborated since the agents concerned in the latter process are wanting. Should this condition of sterility of the soil continue it can no longer produce crops, and were this condition universal the world would become a barren waste.

In every soil a series of complete chemical changes are taking place, due to the activities of soil organisms. These changes involve the digestion of crude plant food whereby an otherwise useless constituent of the soil is put into such a state that it can be absorbed by the plant. Digestion, therefore, implies the rendering soluble of an otherwise insoluble substance.

Nutrition whether applied to animals or plants implies three distinct processes; digestion, absorption and assimilation. Digestion is the rendering soluble; absorption is the taking up of the soluble products, while assimilation is the elaboration of new tissues from the absorbed products.

Substances to be absorbed must be so changed that they will dissolve in the fluids of the organisms, which in the case of an animal, is the blood or lymph, and of the plant, its juices.

Starch taken as food is insoluble in the fluids of the body; it therefore cannot be absorbed until it is converted into a soluble sugar A morsel of lean meat is insoluble, however fine its state of division, hence before it can be absorbed it must be converted during digestion into a soluble pepton.

What is true of the crude elements of animal food is equally true of the crude plant food of the soil. Thus the granule of mineral matter, the bit of bone in a fertilizer, the shred of dried blood or other animal matter, the top and root of the clover turned under—

all these and many other forms of crude plant food are in themselves of no use to the plant until the elements therein are put into such a shape as to be taken up into the juices of the plant through the absorbing rootlets. Furthermore, as we have intimated, this work of digesting the crude plant food of the soil is continually being carried on by myriads of microscopic organisms present in every normal soil. Through their agency nourishment is gradually and continually being supplied to growing crops as rapidly as their needs demand, and there results a beautiful and wonderful relationship and balance between the life of the highest and lowest of the plant creation. The one is dependent upon the other, and independently neither can normally exist.

Such is the general relationship existing between soil micro-organisms and plant growth.

We are thus led to understand the importance of the study of Soil Bacteriology to general agriculture. The more detailed exposition of the subject, together with the relation of its principles to practice. will be outlined in the pages which follow.

I. THE ELEMENTS AND SOURCES OF PLANT FOOD.

Ninety-three to ninety-six per cent. of the dry weight of agricultural plants is organic matter, and is composed mainly of the four elements: carbon, hydrogen, oxygen and nitrogen. The remainder is inorganic or mineral matter which is recovered for the most part in the ash when the plant is burned.

The elements found in the organic portion occur in approximate proportions as follows: Carbon 45 per cent., oxygen 49 per cent. hydrogen 6 per cent. Besides these, nitrogen may exist in amounts varying from 0.5 to 1.0 per cent. of the whole.

The green parts of all plants, but particularly the leaves, inhale and exhale atmospheric air. In the latter is ordinarily contained about four parts of carbon-dioxide for every 10,000 parts of air. Carbon-dioxide is composed of the elements carbon and oxygen in the proportion of one part of the former to two of the latter. It is this compound which furnishes to the plant all of the carbon and a portion of the oxygen.

The roots absorb water, and conduct it to the stem, whence it is carried to the leaves. Water contains the elements hydrogen and oxygen in the proportion of two parts of the former to one of the latter. Water furnishes all of the hydrogen and a portion of the oxygen. In other words, the two compounds, carbon dioxide and water, are brought together in the leaves and a chemical reaction

between the two takes place, under the action of sunlight, by which these elements are combined in such a way as to produce starch.

Starch therefore accumulates in the leaf as a result of this process known as *assimilation.*

The various changes which the starch undergoes, and the manner in which it contributes to the nutrition of the plant, is a matter beyond the limits of our subject. But suffice it to say that 98 per cent. of the organic portion of the plant is manufactured by the process here indicated, so that it may be said that in the main the plant gets its food from the air and from pure water. But these elements alone will not suffice to maintain plant life; in fact no plant can grow without that vital substance within its cells known as protoplasm.

Plants grow by a multiplication of their cells, and cells empty of protoplasm are dead.

Protoplasm, besides containing the elements, carbon, hydrogen and oxygen, also contains about 16 per cent. of nitrogen. Most agricultural plants also contain in their dry water-free state from one-half to two per cent. of nitrogen in the form of proteids.

Plants obtain their nitrogen mainly from the soil, and so important is this element to their growth that a soil may be said to be rich or poor as its contents is high or low in nitrogen. In fact the problem of agriculture to-day is to supply to the soil an abundant store of this essential element.

The nitrogen of the soil is, in the main, stored away in its humus content, hence soils rich in humus are also rich in nitrogen. Thus it is nitrogen which the agriculturist seeks when he migrates to the prairie loams rich in humus, or when he reclaims the forest to possess a virgin soil. In fact it is the nitrogen problem with which the soil bacteriologist is more concerned than with any other, and its importance and bearings will be made more apparent as we proceed.

As has been intimated, from four to seven per cent. of the dry weight of the plant is composed of inorganic or mineral matter. In this portion we recognize, as most important, potash, soda, magnesia, lime, iron, phosphoric acid, sulphuric acid, chlorine and silica.

These occur usually in abundance in all soils, although not always in an available form; in fact many of them exist in an insoluble state and need first to be digested or rendered soluble before they can be absorbed by the plant.

Soil bacteriology is partly concerned with those processes in the soil by which stores of mineral food are unlocked to growing crops. But to understand these processes in full it will be necessary to consider for a moment the question of the origin of soils, and thus trace each step in the operation.

II. SOILS, THEIR NATURE AND ORIGIN.

Rocks form the solid crust of the earth. These when brought under the influence of the atmosphere, frost and percolating waters, etc., are broken and disintegrated, forming a layer of loose materials constituting the soil. The nature of these disintegrations and their resulting products vary with each mineral, and hence the character of the soil is largely dependent upon the mineral composition of the underlying rocks.

Let us take as an example a region underlaid by some rock of the granite family, such as is found under a considerable portion of southeastern Pennsylvania. Such rock will contain the following minerals: Quartz, orthoclase feldspar, plagioclase feldspar, biotite, hornblende, and accessory apatite and magnetite. The composition of these several minerals will be represented in the following table:

Table I.

Name of Mineral.	Chemical Composition.							
Quartz,	Silica.							
Orthoclase,	do.	Alumina.	Potash.					
Plagioclase,	do.	do.		Lime.	Soda.			
Biotite,	do.	do.	do.			Magnesia.		
Hornblende,	do.	do.		do.		do.	Iron.	
Apatite,				do.				Phosphoric acid.
Magnetite,							do.	

From the table it is seen that in the granite rock under consideration most of the mineral elements necessary to plant growth exist, hence a soil formed from its decay will contain the basis of fertility.

The process by which this rock becomes converted into soil is something as follows: The orthoclase, the plagioclase, the biotite and the hornblende in the above list are compounds of silica and alumina, various alkalies and earthy materials as potash, soda, magnesia, lime and iron. These latter compounds are slowly dissolved out of their respective minerals by surface waters, rain and atmospheric moisture, more or less charged with carbonic, nitrous, nitric and various organic acids until there is left behind only the silica and alumina, which combined with water form clay. The hard minerals just mentioned, bound together into a rocky mass are thus converted into a soft plastic material. The quartz on the other hand, remains undecomposed, but its grains are set free by the disintegration of the other minerals, and there results more or less sand, which, mixed with the clay, tends to loosen the latter and give it the character of an arable soil. It is not to be understood that all of the above minerals undergo dissolution uniformily. The feldspars begin to dis-

integrate first, the hornblende next, while the biotite mica remains for a long time unaffected. Thus there results a clay, the final product of the disintegration, mixed with quartz particles, or sand, together with fragments of undecomposed rock of greater or less size, giving the soil its open, porous or even stony character, so common in regions underlaid by the ancient crystalline rocks.

Besides the direct chemical actions already enumerated, other factors in soil formation of a physical nature might be mentioned. These are the expansion and contraction of rock masses; frost and freezing water; plant roots forcing their way into rocky crevices; beating and scouring rain; all tending to disintegrate the rocky covering of the earth and to open it more thoroughly to the subtle action of meteoric waters.

Another type of soils are those formed from the disintegration of limestones. Limestones are impure mixtures of carbonate of lime with various proportions of sand and clay. In the disintegration the great bulk of the carbonate of lime is leached out, and the insoluble sand and clay are left as the final product. Thus a limestone composed of 75 per cent. of carbonate of lime, may when converted into soil contain only a trace of the original carbonate. This residual soil is however more or less rich in the mineral elements of plant food while the as yet undecomposed particles in the residual sand, by continued disintegration, add new food materials to growing plants.

Sandstones undergo disintegration by the solution in meteoric waters of the materials which bind together individual grains. In this way the component sand particles are loosened, together with clay, which is generally an important constituent of most sandstones.

Whatever may be the character of the rock or of its contained minerals the process is the same, i. e., the dissolving out by means of percolating waters of the elements of plant food contained within the minerals. These percolating waters are furthermore made active solvents in the disintegration of rock through the acid products which they contain, which in turn are produced by the decay of organic matter through the agency of micro-organisms. Of the acid products the most active in this regard is carbon dioxide, which is the final product of the decomposition by bacteria of organic matter.

The chemical union between the carbon dioxide in percolating waters and the potash soda lime and magnesia in the minerals, results in the formation of carbonates and bi-carbonates of these bases, which being soluble, are in a large measure carried away in solution so that the residual soil contains but a certain proportion of these original stores of agricultural wealth. This loss of mineral plant

food is illustrated in the following table, in which in the first column are given the percentages of lime magnesia potash and soda in an original gneiss rock, and in the second column the quantities of the same present in the residual soil.

Lime (Ca 0),	4.44	Trace
Magnesia (Mg 0),	1.06	0.40
Potash (K 2 0),	4.25	1.10
Soda (Na 0),	2.42	0.22

The question might here be asked why are not all of these elements of plant food entirely leached from the soil, and in what form are these residual materials held. In most soils a portion of them are locked up in the form of undecomposed mineral particles and fragments of rock, and it is the continued decomposition of these latter which furnish fresh stores of available plant food.

Another important chemical process going on in the soil is the formation of so called zeolitic compounds. As the alkalies, such as soda and potash, are dissolved out of the minerals by carbonated waters the carbonates thus formed possess a certain solvent action upon silica. This dissolved or gelatinous silica combines with the alkalies, resulting in the formation of zeolites. These secondary zeolites thus fix as it were the alkalies, notably potash, which might otherwise be leached from the soil. Furthermore, the especial affinity which potash has for zeolites fixes this, the most important of mineral nutriments, above all others. Thus if a zeolite be composed of silica and soda or of silica and lime, the potash in preference will enter into combination with the silica and the less valuable soda or lime will be set free.

Zeolites differ from the more insoluble silicates found in rock-forming minerals in the fact that they are readily decomposed by acid soil waters, thus setting free to plants their valuable nutrients.

III. THE SIGNIFICANCE OF SOIL BACTERIA.

Active and Potential Fertility of the Soil.

Since the different chemical changes taking place in soils, by which plant food is elaborated and rendered available, are in large measures the result of bacterial action, it is assumed that the larger their numbers, up to certain limits, the greater must be the rate of elaboration of plant food.

This is instanced by the fact that soils which are under active fertilization and cultivation, and which in the popular sense are con-

sidered fertile, are relatively high in bacteria as compared with those in the opposite condition.

In this we must distinguish between active and potential fertility.

A soil is actively fertile when plant food is being elaborated therein at a greater rate than required by the maximum demand of growing crops.

Such soils not merely contain an abundance of crude plant food, but the latter is being actively digested.

Such soils are, furthermore, always high in bacteria, showing that the latter are functionating vigorously under conditions most favorable to them.

A soil is potentially fertile when it is rich in plant food, but owing to unfavorable conditions or environment the soil bacteria are dormant, and thus either cease to digest plant food or do it so inactively as to fail to keep up with the demand of growing crops.

Thus forest and woodland soil are rich in humus and other crude plant food, but owing to their usually acid condition, as well as to their compacted state, the bacteria therein are able to develop but slowly, and but little available plant food is elaborated. Such soils are low in bacteria; but let this virgin forest soil be brought under active cultivation, especially if its acidity be corrected at the same time by means of a liberal dressing of lime, conditions favorable to bacterial life are at once created, the number of bacteria rises, and an actively fertile soil is the consequence.

Old pasture lands and permanent meadows possess potential rather than active fertility. In such soils the number of bacteria is relatively low, and plant food is but slowly digested. But such lands are at once converted into an actively fertile condition when brought under cultivation or when other means to stimulate bacterial life in the soil are utilized.

It is the function of the agriculturist to understand how potential can be converted into active fertility; in other words how land rich in crude plant food can be made large producer of crops.

An average of the results of 49 analyses of typical soils of the United States showed per acre for the first eight inches of surface soil 2,600 pounds of nitrogen, 4,800 pounds of phosphoric acid and 13,460 pounds of potash. The average yield of wheat in the United States is 14 bushels per acre. Such a crop will remove 29.7 pounds of nitrogen, 9.5 pounds of phosphoric acid and 13.7 pounds of potash. Now if all of the potential nitrogen, phosphoric acid and potash could be rendered available there is present in such an average soil, in the first 8 inches, enough nitrogen to last 90, enough phosphoric acid for 500 and enough potash for 1,000 years.

This is what is meant by potential fertility, and yet such a soil

possessing this same high potential fertility, may, under certain conditions, be so actually barren of results to the farmer as to lead him to believe it absolutely devoid of plant food.

A soil at Rothamsted, England, which has been successively cropped to grain for 50 years without the addition of manure, and which consequently had become exhausted especially in available phosphoric acid, still contained a total of 2,880 pounds of phosphoric acid per acre in the first foot of surface.

Of this only 72 pounds per acre was soluble in a one per cent. citric acid solution. In other words, a soil which contained enough total phosphoric acid to support a wheat crop for 300 years, had, as a result of 50 years successive cropping, its store of available phosphoric acid so reduced as to leave a supply sufficient to last only between seven and eight years. This case is typical of thousands of others, and is illustrative of what is meant by soil exhaustion. It consists in using up original supplies of available plant food at a greater rate than they are being manufactured in the soil. Most of the older lands of the Atlantic seaboard which have been regarded as "worn-out" and exhausted are in much the same condition. Nevertheless they still contain large stores of unavailable plant food, which it only requires the application of modern agricultural practice to unlock. In other words, soils still potentially fertile must be made actively so, and since soils potentially fertile are low and those actively fertile high in bacteria, it would appear that one of the primary requisites of active fertility is to fulfil those conditions of the soil which favor the best development of bacterial life therein.

Numbers of bacteria in soils thus become an index of active fertility.

IV. METHODS OF DETERMINING THE NUMBER OF BACTERIA IN SOILS.

1. Drawing the soil sample. The determination of the number of bacteria in the soil of a given area involves an elaborate and careful preparation of the sample.

Studies at the Delaware Experiment Station have shown that the numbers vary considerably within rather narrow horizontal ranges, and thus to obtain an average sample, representative of an entire field, implies the collection and mixing of a large number of smaller samples. For most studies it will be sufficient to collect the first nine or twelve inches of soil, and for this a wood auger one inch in diameter is very satisfactory.

To preserve the boring intact a device such as is shown in Fig.

FIG. 1.—Apparatus for drawing soil samples.

I, is used. It consists of a circular plate of copper, six inches in diameter, in the centre of which is a circular hole, one and a fourth inches in diameter, from which rises at right angles to the plate a copper tube of the same diameter and twelve inches long. The ground where the boring is to be made is cleared of all vegetation and the copper plate set firmly and held in place by both feet. The auger is then inserted into the copper tube, which should stand vertical to the ground surface, and the auger turned until the required depth is reached, as determined by graduations on the stem of the auger. The auger is then drawn gently from the ground and into the copper tube until the core of earth is enclosed in the latter, and thus kept intact. The earth is then emptied on a sheet of clean paper.

In getting an average sample for an entire field, borings should be taken along two intersecting lines diagonally across a field at intervals of ten or twenty feet according to the size of the plot. These separate borings are emptied into a clean box until the work is finished. The collected soil is then sifted through a No. 10 sieve, reducing the lumps but discarding stones and gravel. The sifted soil is then very thoroughly mixed, and from this a sample of about two pounds is taken to the laboratory.

The latter sample is sifted through a brass sieve of a one-millimeter mesh, and any lumps or coarse particles are reduced in a mortar until the entire sample has been made to pass the meshes of the sieve. The whole is then very thoroughly mixed and from this a small sample of about twenty grams is taken. This is then sifted through a 0.5 millimeter brass sieve which has been made sterile in a bath of boiling water, and dried over the bare flame of a bunsen burner. Any lumps or coarse particles which do not readily pass the sieve are rubbed in a sterile mortar until the last portion has passed. The siftings are then thoroughly mixed, transferred to a sterile test-tube and tightly corked.

2. *Making the analysis.* In a weighed glass-stoppered weighing-bottle approximately 0.5 a gram of the sample is placed, and the exact weight determined. The soil sample is transferred to a small sterile mortar and with a small quantity of sterile water rubbed to a fine mud, after which the last trace of soil in the weighing-bottle is transferred to the mortar by washing with sterile water.

The supernatant muddy water in the mortar is then transferred to a 100 c. c. flask containing sterile water; more water is added and the residue triturated; again transferred to the flask, and the operation continued until all of the soil in a finely divided state has been washed into the flask. The latter is then filled to the 100 c. c. mark with sterile water, and the contents vigorously shaken for exactly two minutes. One c. c. of this turbid water is then transferred to a

second 100 c. c. flask, and filled to the mark with sterile water, shaken for one minute, and 1 c. c. of the dilution transferred to a tube of melted gelatin (5 c. c. in each tube), the latter gently rocked, and the contents poured into a Petri dish. The gelatin is made to solidify rapidly on a cold plate, and then placed in a cold water incubator for four days. At the end of this time the number of colonies on the plate are counted.

The result of the analyses are expressed in number of bacteria per gram of dry soil, hence it becomes necessary to know the percentage of moisture in the sample. For this a given weight of soil from the same tube is taken, and dried for three hours at 100° C., and from this the percentage of dry matter in the sample is calculated.

It is evident that in the mixing of the soil with water in the two 100 c. c. flasks there is in the 1 c. c. taken for the plate culture a one ten-thousandth dilution of the original quantity, hence the number of colonies on the gelatin plate must be multiplied by 10,000 to get the true number in the quantity of moist soil taken. To calculate the number per dry gram of soil the following formula is used:

$$N = \frac{N' D}{P W}$$

in which N equals the number of bacteria per gram of dry soil, N′ the number of colonies on the gelatin plate, P the percentage of dry matter in the sample, D the dilution of the soil sample (in most cases 10,000), and W the weight of the moist soil taken for bacteriological analysis

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V. THE NUMBER AND DISTRIBUTION OF SOIL BACTERIA.

In the superficial portion of ordinary cultivated soil the number of bacteria varies from several hundred thousand to several millions per gram of dry soil. The following list will show the range of variation as observed by different authors:

1. Park Montsouri, Paris (Miquel. 1879),[2] 700,000
2. Sandy soil (Adametz, 1886),[3] 300,000
3. Clay soil, ... 500,000
4. Orchard, Potsdam (Fraenkel, 1887),[4] ....31,000 to 218,000
5. Soil of grain fields (Caron, 1895),[5] ....937,000 to 1,600,000
6. Pear orchard, Del. Expt. Sta., ground under high state of cultivation (Chester, 1901),[6] 2,200,000
7. Land in permanent grass for over 12 years, Newark, Del. (Chester, 1901),[6] 425,000
8. Land in grass for four years, Newark, Del. (Chester, 1901),[6] 425,000

9. Land, Newark, Del., under active cultivation during summer, now in crimson clover (Chester, 1901),[6]	1,880,000
10. Soil from the center of a strip of woodland, Newark, Del. (Chester, 1901),[6]	70,000
11. A family vegetable garden, Newark, Del. Rich in humus and actively cultivated,[6]	1,816,000

The preceding table, except No. 10, represents agricultural soils. In special instances the number may rise much higher, particularly in soils in the immediate vicinity of dwellings and stables. According to Manfredi,[2.1] the number of bacteria in the dust of the streets of Naples varied from 1,000,000 to 10,000,000 per gram, and even higher. Maggiora[2.2] gives figures as high as 78,000,000 for the number of bacteria per gram of soil in certain inhabited spots.

Adametz in 1886,[3] Fraenkel[4] in 1887, and Caron[5] in 1895, showed that the maximum number of bacteria were not found at the surface but at a depth of from nine to eighteen inches beneath the same.

In 1887 Fraenkel[4] showed that at a depth of from thirty to sixty inches there was a rapid and abrupt diminution of the number of germs from 200,000 at twenty inches, to 2,000 at thirty-nine inches, while at a depth of five feet no living germs were obtained. These results are not altogether in accord with results obtained by the writer in Delaware, which show that the maximum number of bacteria occurs in the first six inches of soil, below which they diminish at a very rapid rate, until at twenty-four inches only about one-five-hundredth of the number at the surface exist. Furthermore, it was found that the highest numbers exist not at the surface, but at a depth of about four inches below the same. In the following figure 2 is shown the rapid decline in the number of bacteria in the soil as the depth increases, determined at the Delaware station.

VI. CONDITIONS AFFECTING THE NUMBER OF BACTERIA IN THE SOIL.

The observations of Maggiora in 1887 have shown (1) that the number of germs in desert and forest soil is much smaller, other things being equal, than in cultivated lands; (2) that the number is proportionate to the activity of cultivation and the strength of fertilizers used, and (3) that light sandy soils contain fewer germs than those rich in clay and especially those rich in humus.

These results are in accord with those given in the preceding table, which show (1) the very low number present in woodland soil, (2) the very high number present in soils under active cultivation

and (3) the relatively low number in soils covered with sod. The reason for these differences is apparent. Woodland soils, although rich in humus, are usually too acid for the best development of bacteria therein. Pasture lands, or lands for a long time in sod, are too compacted or imperfectly aerated. Most soil bacteria develop best in the liberal presence of atmospheric air, hence the opening up of such soils by tillage to the action of the atmosphere is essential before the best development of bacteria can take place. Pasture lands also have a tendency to become acid, a condition unfavorable to bacterial development.

In the studies at the Delaware Station, the highest numbers of bacteria were always found in soil which had been under active cultivation, especially when liberally supplied with humus, either by plowing under of green crops or by the use of stable manure. Thus in soil No. 6, of the preceding list, where the number of bacteria was 2,200,-000 per gram, the latter had been enriched by repeated crops of crimson clover plowed under, accompanied by active tillage. Soil No. 11, a vegetable garden, had annual dressings of stable manure for a series of years, and had also been under constant tillage. The value of stable manure in increasing the number of bacteria in the soil has been shown by Miquel,[2] who found that after the application of this fertilizer the number of bacteria in the soil was increased from 700,000 to 900,000 per gram.

It may therefore be stated as a general principle that *the combined effect of high manuring and cultivation is to decidedly increase the number of bacteria in the soil, thus in turn setting free an increased quantity of available plant food.*

Soil Bacteria in Their Relation to Atmospheric Oxygen.

It has been stated that the great majority of soil bacteria develop best in the presence of atmospheric oxygen. Bacteria differ as regards their relation to this important element, and thus it has been the custom to divide them into three classes, (1) obligate aerobes, or those which do not grow except in the presence of oxygen; (2) anaerobes or those which grow only with the complete exclusion of oxygen, and (3) facultative anaerobes or those which are indifferent to the presence or absence of this gas. In recent times it has been recognized that no such sharp lines as these can be drawn; on the other hand these different classes merge into one another by indistinct stages of gradation.

A bacterium may, in a measure, show the ability to grow with the partial or complete exclusion of atmospheric oxygen, but it grows

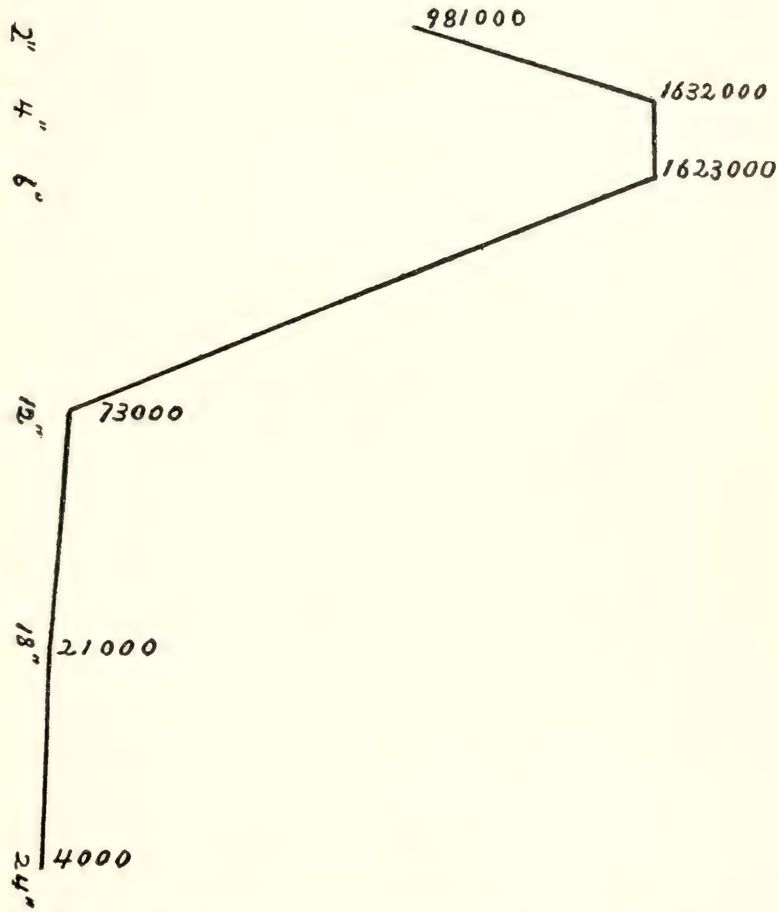

FIG. 2.—Showing number of Bacteria in different depths of soil. Experiment Station Grounds, Newark, Delaware, September 21, 1901.

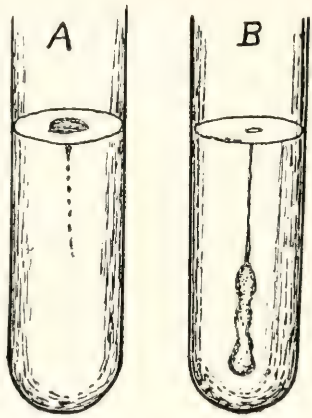

Fig. 3.—A showing ærobic growth, and B anærobic growth of bacteria in gelatin stab cultures.

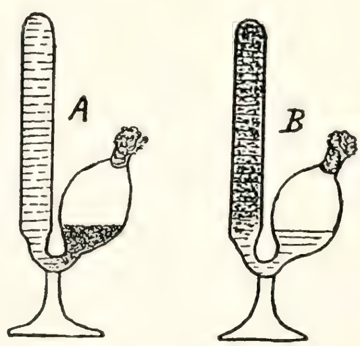

Fig. 4.—A showing ærobic, and B anærobic growth of bacteria in glucose bouillon in fermentation tubes.

less vigorously than when air is freely admitted; in this case the tendency is towards an anaerobic habit, but such a habit may not be fixed, and it may be changed in a measure by cultural conditions under the control of the bacteriologist. That is, an organism which has a slight anaerobic habit can be made to grow more and more freely with the exclusion of atmospheric oxygen. The relation of bacteria to atmospheric oxygen may manifest itself in a number of ways.

Thus if a fine sterile platinum needle be dipped into a bacterial culture, so that its surface becomes covered with a particular germ, and if this contaminated needle be then stabbed into a tube containing solid nutrient gelatin, a medium in which bacteria grow readily, the latter are, so far as food material is concerned, free to grow at all points along the line of stab, and their development is only limited by their ability to grow in the presence or absence of atmospheric oxygen. If growth takes place as well in the depth of the medium, where air is excluded, as it does at the surface where air is abundantly present, such an organism is clearly indifferent to its atmospheric environment. If on the other hand no growth takes place in the depth of the gelatin, but only on the surface, the organism would be aerobic in habit, as shown in Fig. 3 A, or again if the growth be confined to the deeper portion of the line of inoculation with no growth at the surface, the organism would show the oposite or anaerobic habit, Fig. 3 B. Between these extremes there will in different bacteria be seen to be a wide range of variation. In the different soil bacteria so far studied there was but little tendency for them to grow in the depth of the gelatin, practically all of the growth taking place at the surface, thus showing the generally aerobic habit of the great majority of them.

Another valuable method of demonstrating the relation of an organism to atmospheric oxygen is by means of a culture in a fermentation tube, seen in Fig. 4, containing beef broth to which two per cent. by weight of grape sugar has been added. In the fermentation tube it is noticed that one end of the same is open and exposed to the air while the other is closed and excluded from the air. If bacteria are disseminated throughout the broth in the tube, they will be free to develop in either arm as they find atmospheric oxygen favorable or unfavorable to their growth. Thus if the growth is confined to the open arm of the tube the organism concerned is aerobic, Fig. 4 A, and if confined exclusively to the closed arm, Fig. 4 B, anaerobic in habit, while if an equal amount of growth takes place in both arms it is indifferent to atmospheric oxygen and is consequently facultative anaerobic in habit.

Of ten of the most common soil bacteria recently studied by the

writer, eight of them grew only in the open end of the fermentation tube, thus showing, in addition to the character of the growth in gelatin stab cultures, their distinctly aerobic habit.

In Fig. 4 A, is shown a culture in a fermentation tube to which was added 1 c. c. of a watery infusion of soil from the Delaware Station experimental grounds. In this 1 c. c. of infusion, something like 10,000 bacteria were introduced, out of the total of 1,000,000 present in the same, or one out of every hundred. It is therefore reasonable to assume that in this way at least the most important and predominating bacteria were introduced. As a result it is seen that all of the growth is confined to the open end of the tube. *Hence we may believe that at least the predominating bacteria of this soil were distinctly aerobic in habit.*

2. The Relation of Bacteria to Moisture.

One of the primary requisites of bacterial growth is the presence of moisture. If a soil becomes perfectly dry, not only do bacteria cease to multiply therein, but a large proportion of them die. It is the organic and in a slight measure, the inorganic materials in solution in the soil moisture which supply food for bacteria, hence the maintenance of soil moisture is one of the essential requisites for bacterial development. In short, those moisture conditions which are most favorable to the plant are likewise equally favorable to the bacteria of the soil. A free and uniform distribution of soil moisture is furthermore essential to a uniform distribution of bacteria, and hence to the active elaboration of plant food in all parts of the soil. It is clear that when the soil becomes dry to a considerable depth bacteria cease to develop and with it the digestion of plant food ceases; hence the maintenance of soil moisture by proper methods is important.

3. Relation of Soil Bacteria to Organic Matter and Humus in the Soil.

Inasmuch as organic matter and humus furnish food for soil bacteria it might be presumed that the greater the amount of such materials present the greater would be the number of bacteria and hence the greater the amount of plant food digested. Such is the case only within limits. If a solution be prepared containing one per cent. by weight of beef pepton, and be seeded with a soil organism capable of converting the pepton into ammonia and other decomposition

products, a vigorous growth will take place, and a relatively large amount of decomposition products will be quickly formed; but soon active growth will cease, and that before the full amount of the original pepton has been completely decomposed. In short, the organism has been either killed or its energies have been paralyzed by the products of its own growth, which in this case have been produced in relatively large amount in the more concentrated solution. If on the other hand a solution be prepared containing only the one-hundredth of one per cent. of pepton, and be seeded with the same organism, growth in the latter medium will be relatively slow, with a correspondingly slow development of ammonia; but the decomposition will continue until all of the pepton has been decomposed. Furthermore, the activity of the decomposition will be as great at the end as at the beginning of the process, showing that the vitality of the organism has not been impared. This is doubtless because in the dilute solution the toxic products are not sufficiently concentrated to injure the life of the micro-organisms.

What is true here would be equally true of the state of concentration of the organic matter in the soil. If the latter be present in excessive quantity bacterial development will proceed for a time at an excessive rate, but soon products injurious to their best development will be produced. There is, therefore, a limit to the amount of humus which a soil should contain.

In forest and woodland soils the amount of humus in the surface layer is large. In such soils organic acids are generated in quantities too large for the best development of bacteria, and hence, as is found to be the case, the number of bacteria is low.

It has been shown that nitrification practically ceases in forest soils, due doubtless to the fact that the nitrifying bacteria, more than any other, are injured by high acidity and excessive humus.

The only condition which renders possible the addition of large stores of humus to the soil is subsequent tillage, which so stimulates bacterial growth as to lead to the destruction of organic acids, or to the production of ammonia, which neutralizes them. *Hence when a crop of clover or other legume is plowed under it is best followed by a cultivated or hoed crop.*

4. The Relation of Soil Acidity to the Number of Soil Bacteria.

It is important to know the conditions of the soil which are most favorable to the rapid development of soil bacteria. Among these nothing is so important as to maintain a proper reaction of the soil. Acid soils are infertile because soil bacteria, which are digesters of plant food, cannot grow therein. We say that lime when applied to

land, among other benefits, assists in the decomposition of organic matter. This is true only indirectly. The lime neutralizes the acidity of the soil and renders it a more favorable medium for the development of those bacteria which are the true agents in the decomposition.

In determining the number of bacteria in soils it is necessary to use a medium the reaction of which is such that the maximum number will develop. Thus from a given dilution of a soil with water an average of seventy-two colonies developed in neutral gelatin, while with the presence of 0.25 per cent. of free alkali an average of thirty-four colonies developed, and with .07 per cent. of free hydrochloric acid an average of only one colony developed. Increasing quantities of citric acid added to the medium had the same retarding action, showing that with a distinctly acid condition of the medium but few soil bacteria would grow.

Of the different species of bacteria isolated by the writer from soils, none grew in a medium containing one-tenth of one per cent. of free hydrochloric acid, and either not at all or only feebly in one containing one-half of this acidity. All, however, grew in neutral media or in those feebly alkaline. A marked excess of caustic alkalies in the medium, approaching .02 to .03 per cent., had a retarding action on the growth of the bacteria, but where the less caustic bases like lime were added a considerable excess proved favorable.

The valuable results from lime added to neutral gelatin media is shown in the following table, in which is given the number of colonies developing in media containing different amounts of milk of lime, seeded with the same quantity of a one-ten-thousandths dilution of a soil infusion:

Table II.

Calcium Hydrate (Ca $(OH)_2$) Present in Medium.	Number of colonies which developed in the medium.
.44 grams per 100 c. c.,	67
.08 grams per 100 c. c.,	75
.12 grams per 100 c. c.,	82
.16 grams per 100 c. c.,	91

The valuable results from the use of lime seem to depend partly on the fact that it stimulates the development of soil bacteria. This was shown in certain pot experiments conducted by the writer.

Pots were filled with soil to which was added an equal quantity of clean gray stream sand.

To pots one and two nothing was added.

To pots three and four was added lime at the rate of 1,000 lbs. per acre.

To pots five and six was added lime at the rate of 2,000 lbs. per acre.

To pots seven and eight was added lime at the rate of 4,000 lbs. per acre.

The number of bacteria per dry gram of soil in each pot was determined at the beginning of the experiment, and again seven weeks later.

The results are shown in the following table:

Table III.

Pot. No.	Number of Bacteria Per Gram of Dry Soil.	
	At beginning of the experiment.	Seven weeks later.
1 Nothing,	441,000	440,000
2 Nothing,	567,000	395,000
3 1,000 lbs. lime,	734,000	1,026,000
4 1,000 lbs. lime,	703,000	2,076,000
5 2,000 lbs. lime,	908,000	1,325,000
6 2,000 lbs. lime,	406,000	1,319,000
7 4,000 lbs. lime,	457,000	4,481,000
8 4,000 lbs. lime,	504,000	6,662,000

The preceding experiment has been repeated with the same result, sufficient to demonstrate the value of lime, at least in the type of soils under consideration, in increasing the number of bacteria therein.

VII. THE CHEMICAL CHANGES PRODUCED BY BACTERIA IN THE SOIL.

The Elaboration of Plant Food.

The processes going on in the soil by which plant food in its crude state is prepared for the use of the growing crop are two, (1) the decay of organic matter and (2) the disintegration and disolution of mineral matter. They will be accordingly considered in turn.

1. The Decay of Organic Matter.

Organic matter, whether of animal or vegetable origin, when freshly incorporated with the soil, undergoes a partial and incomplete process of decay resulting in the production of a dark material known as humus.

The amount of humus in soils may vary from one per cent. in the soils of the arid region of the West to as high as five per cent. in black prairie loams.

The original supply of humus in virgin soils becomes a constant source of plant food through its slow but constant decay. Long continued cropping and tillage produces in time, however, a "burning-out," which means that the humus content of the soil is being gradually reduced. Thus according to Snyder,[8] a virgin soil with four per cent. of humus will, after twenty years of grain cropping, show a reduction to 2.5 per cent. of the same material.

2. Forms of Organic Matter in the Soil.

Organic matter becomes incorporated with the soil largely in the form of vegetable materials such as fallen leaves, sticks, seeds, straw, stubble, sod, the roots of various plants, green crops turned under, etc.

Such vegetable matter of whatever kind is composed of a framework of cells constituting its woody portion. The material constituting the walls of these cells is, for want of a better term, designated as cellulose, since the latter substance in one form or another predominates. Within the cavities of the cells, partially or completely filling them, may be found certain organic substances of which the most important are: (1) proteid matter, including protoplasm, proteid granules, aleurone and gluten; (2) carbohydrates, including starch, grape sugar, cane sugar, vegetable mucilage, gums; (3) fats and oils. Besides these are small quantities of a great variety of other substances, as glucosides, tannin, alkaloids, essential oils, resins, balsams, turpentine, coloring matter, etc. Notwithstanding the great variety of plant products, the principal materials, forming practically

the entire bulk of plant structures, are included under the heads (1) cellulose, (2) proteid matter, (3) carbohydrates and (4) fats and oils. The decomposition of these several materials in the soil will be considered each in turn.

3. The Decomposition of Cellulose or Vegetable Fibre.

That straw and bits of woody fibre become soft and finally disappear as such when incorporated with the soil is a fact of common observation. Leaves and stems when mingled with earth rapidly lose their structural characteristics and become converted into a shapeless mass of mould. The log or stump under the action of biological and chemical agents decays more slowly, but eventually looses its structure and becomes converted into a brownish pulverent debris.

These changes involve the fermentation of cellulose or vegetable fibre, and are of special interest. The walls of vegetable cells are composed of matter more or less complex in character; but since cellulose in one form or another constitutes the basal portion of all cell walls, it has been common to refer to them as composed of this substance. But more accurately speaking cellulose is now understood to include a large class of plant constituents.

These latter may be grouped under two heads: (1) the celluloses and (2) the pectoses. The walls of different cells differ in the relative proportion of these two classes of bodies. Thus the walls of cells which constitute so called succulent or parenchyma tissue are relatively rich in pectoses. This is particularly marked in the flesh of fruits. Cellulose differs in its properties and ability to undergo fermentative changes. In the latter respect cotton fibres are the most resistant and the cellulose of seeds the least so, while that found in the fundamental tissue of the higher plants occupies an intermediate position. With the difference in the constitution of the cell walls of plants there results a marked divergence in their ability to undergo fermentative changes, and also a difference in the products of such fermentation. For this reason the fermentative decomposition of cellulose becomes an extremely complex phenomenon.

The dissolution of cellulose is brought about by the action of a ferment or *enzyme* known as *cytase*.

In 1886, DeBary,[9] found in the fungus *Peziza sclerotiorum* a substance which possesses the property of causing cell walls to swell, become gelatinous, and in a measure to dissolve. Two years later H .Marshall Ward,[10] found that a similar ferment was secreted by a species of Botrytis, commonly associated with the soft rot of a number of cultivated plants.

In his study of the latter, the author observed minute drops ex-

uding from the filaments of the fungus, and in this exuding fluid was found a ferment in concentrated form, possessing the power when coming in contact with cell walls of softening and dissolving them. It was also observed that the ferment acted differently on different portions of the cell wall, and that its action was first upon the middle portion, or what is technically known as the *middle lamella*. This was followed by a swelling of the remainder of the wall, and by the appearance of distinct stratifications, which dissolve one by one in turn. In the swelling of the cell walls the latter assume a semi-mucilaginous consistency which has the effect of softening the entire tissue. Thus plants attacked by cytase secreting fungi, such as the ones named, undergo a species of soft rot.

In addition to the preceding observations Kean and Arthur[11] have recently shown that the fungus *Rhizopus nigricans* also secretes a cellulose dissolving enzyme. This latter fungus is a common cause of a soft rot of the sweet potato, a result in accord with the properties of the fungus. It is, furthermore, probable that a large variety of fungi associated with the soft rots of fleshy fruits and roots, possess the same property of secreting cellulose enzymes.

A number of the higher toad-stools and shelf-fungi, are associated with dry rot of timber, in which process the hard wood becomes converted into a brown pulverent mass. This disintegration is affected, it is now believed, through the ability of these several fungi to produce enzymes capable of softening and in a measure at least of dissolving cellulose or woody tissue.

Besides the fungi proper, certain bacteria have been shown to possess the ability to ferment cellulose. Thus as early as 1850, Mitscherlich[12] made the observation that cellulose could become soluble by fermentation. In the fermentation of the potato for instance he found the cell walls dissolved, and associated with this change he noted the presence of a species of Bacterium. In 1875, Popff[13] noted the relation between the degree of fermentation of cellulose and the development of certain gases, as carbon dioxide (CO_2) and marsh gas (CH_4). Later, in 1879, Van Tieghem showed by experiment that a solution of cellulose was effected through the action of a micro-organism related to *Bacillus amylobacter*. During the change, hydrogen gas was generated, also an acid, whose presence gradually hindered the fermentation process. Van Tieghem's observations that the fermentation of cellulose was due to the latter B. *amylobacter* was confirmed by Hoppe-Seyler[15] in 1886.

This fermentation as originally shown by Popff, and later by Hoppe-Seyler and Schlösing, was accompanied by the vigorous evolution of carbon dioxide and marsh gas, and took place in the absence of air.

The process consisted probably in an hydration of the cellulose, and its conversion into dextrose or a related body, and the subsequent fermentation of this secondary product as shown by the following formulae:

$$(1)\ C_6 H_{10} O_5 + H_2O = C_6 H_{12} O_6$$
$$(2)\ C_6 H_{12} O_6 = 3\ CO_2 + 3\ CH_4$$

In 1890, Von Senus[16] showed that the fermentation of cellulose was not due to the action of B. *amylobacter* alone, but to its concurrent action with other organisms. In 1895, Omélianski[17] announced the discovery of a bacillus capable of fermenting pure cellulose, which he obtained from slime and soil rich in vegetable matter.

In the experiments of the author filter paper or cotton, representing cellulose in its purest form, was immersed in a solution containing sulphate of ammonia, pepton and asparagin and into this culture medium the organism was introduced. The beginning of the fermentation was shown by the liberation of gas in from 6 to 10 days. An examination of the filter paper in from 3 weeks to a month showed an advanced stage of decomposition, and in from 3½ to 5 months 79 per cent. of the cellulose had been destroyed. The products of the fermentation were found to be carbon dioxide, hydrogen, volatile organic acids and minute quantities of the higher alcohols.

Whether bacilli identical with *B. amylobacter* of Van Tieghem, or the Bacillus of Omélianski, are found in all soils is a matter yet to be determined, but it is believed that organisms with similar functions are present in abundance. Furthermore, whether these bacteria decompose cellulose through their ability to secrete enzymes has also to be determined. DeBary in referring to *B. amylobacter* says it decomposes cellulose forming dextrin and glucose, and that it does so by disengaging an enzyme.

Although the experimental proof of this is lacking it is probable that the assumption is true.

Baccillus mesentericus-vulgatus, a common soil species, has been shown by Vignal[18] to secrete a cytase which dissolves the middle lamella of vegetable cells.

There is therefore every reason to believe that numerous organisms capable of fermenting cellulose exist in soil, and that they act upon cellulose, like the higher fungi, through their ability to produce cytase.

The action of cytase upon cellulose is to incite a chemical union of water with cellulose, a process known as hydrolysis, and is an action similar to that which takes place when cellulose is boiled in

dilute acids. It consists in the conversion of the cellulose into some form of sugar, which differs with the forms of cellulose acted upon. These different forms of sugar are glucose, mannose, galactose, zylose and arabinose.

The pectoses, which have been found also to be important constituents of the cell wall, are under the action of cytase converted into reducing sugars. The different forms of sugar are then acted upon by other ferments and converted into organic acids.

This explains the common tendency of soils rich in vegetable matter to become acid, unless continued cultivation stimulates bacterial growth sufficient to decompose these less readily decomposable organic acids into their final gaseous products, carbon dioxide and marsh gas.

It has already been noted that all of the constituents of cell walls do not undergo dissolution equally. Hence when vegetable fibre undergoes fermentation in the soil there remains a residue which for a longer time withstands the action of these ferments. This latter constitutes the great bulk of that heterogeneous material which is called humus. Humus is, therefore, in the main, the product of the incomplete decomposition of vegetable fibre.

4. The Fermentation of Carbohydrates.

The carbohydrates in vegetable tissues exist mainly in the form of starch and sugar. In crops ordinarily used for green manuring they constitute between 40 and 50 per cent. of the dry weight of the plant. Starch is the most abundant carbohydrate of green crops, but sugar exists in small amounts, usually a fraction of a per cent. However, in fleshy roots, fruits, and in special cases, it may run much higher, reaching a maximum in the beet and sugar-cane of 15 per cent.

Sugar exists in different vegetable tissues in three forms: as cane sugar or saccharose, grape sugar or dextrose and fruit sugar or levulose. In animal tissues and fluids the carbohydrates exist: as glycogen, a modified starch, as dextrose, and in milk as milk sugar or lactose.

Bacteria play an important role in the fermentation of carbohydrate, and those concerned in these processes are abundantly present in all soils. The great majority of bacteria when growing in media containing grape sugar, milk sugar or cane sugar produce therein greater or less quantities of organic acids accompanied in some cases by the evolution of gas.

These acids are lactic, acetic, butyric, formic, propionic, valerianic and succinic. When milk sours, lactic acid is produced at the expense of the milk sugar by certain bacteria normally present in the

fluid. Fruit juices and infusions undergo an apparently spontaneous fermentation, the sugar being converted into alcohol through the agency of the yeast plant, with the subsequent conversion of the alcohol into acetic acid.

Many bacteria are, however, capable of directly converting sugar into one or more of the organic acids, without the intervention of alcohol; in fact, it may be said that the ability to convert sugar into one or more of the organic acids is almost a universal property of bacteria, although they vary among themselves as regards kinds and quantities of acids produced.

In order to better understand the fermentation of the different carbohydrate constituents of plants, it will be best to consider them in turn.

(*a*) *The Conversion of Starch into Sugar.* When seeds germinate, a marked change takes place, the most notable of which is an alteration and an eventual solution of the starch granules which fill the cells. In proportion as the starch disappears there is a corresponding increase in sugar. In the preparation of malt from barley the same change takes place. The barley grains are allowed to sprout under favorable conditions of heat and moisture, during which a considerable proportion of the insoluble starch is converted into a soluble sugar. If a quantity of this malt be steeped in water, especially if the malt be macerated to a pulp, the greater portion of the sugar, a part of the soluble starch and dextrine bodies and other extractive matter pass into solution. If a portion of this extract of malt be allowed to act upon starch it will be found to possess the power of converting the starch into sugar. Furthermore, if several volumes of strong alcohol be added to a volume of the malt extract a whitish precipitate will be thrown down, which can be collected on a filter and redissolved in a small quantity of water. If now this watery solution be allowed to again act upon starch, it will be found to possess properties identical with that of the simple infusion.

Malt extract, therefore, contains a substance which is precipitated by alcohol and which has the power of converting starch into sugar. This substance is called *diastase* or *amylase.*

Diastase has an important function in relation to the nutrition of plants. Plant food exists largely in the form of starch, but which in this shape is of no use, since it is insoluble and therefore incapable of being carried in solution to growing parts; in short, the starchy food of the seed must be digested before it is available, and this digestion is effected through the agency of diastase. Similarly, starch is formed in the leaves and other green organs of the plant, but before it can be utilized as food it must be converted into sugar. To effect this change diastase is present in all leaves and organs where

starch is being elaborated. Many trees store up during the winter reserve material in the form of starch which becomes food for unfolding buds on the advent of spring. Thus Desbarres[19] found in the young wood of *Rhus elegans* 17.31 per cent. of starch during the winter and only 1.57 in the spring.

The sugar maple yields in the early spring a sweetish sap which is produced from the reserve starch accumulated in the wood during the preceding fall.

Many roots and tubers are notable for their large content of starch, which, in all biennial plants, serves as food for a second season's growth. When potatoes sprout they draw largely upon the starch of the tuber, and with the elongation of the sprouts we note a dimunition of the starch and an increase of sugar. With this there is an accumulation of diastase in the tuber at the points where the sprouts originate.

In refering to the fermentation of cellulose, it was stated that it is a common function of many enzymes, of which diastase is one, to effect the hydration of certain organic substances, or their union with water.

The hydration, or conversion of starch into sugar, is a complex process, not as yet altogether understood, but the two products of the change are evidently maltose and dextrin. It can perhaps be expressed according to Musculus[20] by the following:

$$\frac{2\,C_{12}H_{20}O_{10}}{\text{starch}} + \frac{H_2O}{\text{water}} = \frac{C_{12}H_{22}O_{11}}{\text{maltose}} + \frac{C_{12}H_{20}O_{10}}{\text{dextrin}}$$

Dextrin, which is a residual product of the partial hydration of starch does not, however, remain as such, but is eventually converted into maltose.

When vegetable materials are incorporated with the soil, it is not likely that bacteria play a very important role in the conversion of this contained starch into sugar. On the other hand the change is likely brought about by diastases normally present in the plants themselves, and the greater part of this transformation is effected before bacteria have time to reach the starchy materials within the cells. Thus in the decomposition of vegetable matter in the soil, much at least of the fermentation of starch is a process quite independent of the action of bacterial life. This does not indicate, however, that certain bacteria and fungi are not capable of effecting this change, in fact Fermi[21] has shown that a considerable number of bacteria secrete diastatic enzymes, notably, *Bacillus megatherium*, *Bacillus, mesentericus-vulgatus* and *Bacillus subtilis*, forms commonly present in the soil; and it is likely that a residual portion of unchanged starch may be acted upon by such organisms, though this

statement will require experimental proof. It is also known that certain common moulds, for example, *Pennicillium glaucum*, *Aspergillus niger and Erotium oryzae*, possess the power of converting starch into sugar.

As already mentioned, the action of diastase upon starch consists in its conversion into maltose and dextrin, but maltose has only a temporary existence in the animal and plant organism, since it is acted upon by another enzyme known as *glucase*, which further hydrolyses the maltose converting it into glucose. Thus glucose is the final product of the fermentation of starch.

Glucase is present in the digestive fluids of the human body. It has been found in corn and malt, and in several species of fungi. That it probably exists in association with diastase in plant tissues is made probable by the fact that maltose as such is unable to nourish growing cells.

(*b*) *The Inversion of Cane Sugar.*—When a solution of cane sugar is boiled with a dilute acid it undergoes an hydrolysis by which it is converted into glucose and levulose according to the equation:

$$\frac{C_{12}H_{22}O_{11}}{\text{cane sugar}} + \frac{H_2O}{\text{water}} \quad \frac{C_6H_{12}O^6}{\text{glucose}} + \frac{C_6H_{12}O_6}{\text{levulose}}$$

That the same change can be effected through the agency of an enzyme has been known ever since the latter was first isolated from yeast in 1860 by Berthelot.[22] This enzyme is known is *invertin*. It has also been found in the intestinal juices of man and a number of animals, and from various parts of plants as leaves, seeds, roots and floral organs.

Cane sugar is found often in considerable amounts in plant tissues, and yet as such it is of no direct use as a plant nutrient, but must first be digested or converted into glucose. Thus the beet may contain 15 per cent. of cane sugar. When, however, the latter is drawn upon for the production of flowers and seeds during the second year's growth it has been noted that its content of cane sugar gradually diminishes and glucose takes its place, the latter being traced in its ascent from the root to the developing leaves and flowers. Thus the presence of cane sugar in the plant implies the existence at the same time of invertin. The first step therefore in the fermentation of cane sugar is its conversion into glucose through the agency of its associated *invertin*.

This change like the action of diastase is also one which takes place in the soil independent, in a large measure at least, of bacterial action.

According to Fermi[21] and Montesano the production of invertin enzymes by bacteria is uncommon, although certain prevalent soil

species, such as *Bacillus megatherium*, *Bacillus fluorescens-liquefaciens and Bacillus vulgaris*, are known to produce them.

The action of invertin is favored by the presence of small amounts of acid; it is therefore likely that in the acid fermentation of plant tissues and the normal presence of invertin ferments there is every condition favorable for the conversion of all the cane sugar into glucose independent of the action of bacteria or other micro-organisms.

(*c*) *The Fermentation of Glucose.*—From the foregoing statement it has been seen that all of the carbohydrates mentioned are eventually converted into glucose mainly through the action of enzymes. It is in this form that they are supplied to the various soil organisms. Through their agency glucose is converted into the various organic acids, into one or more of the alcohols, with or without the evolution of gas in the form of carbon dioxide and hydrogen.

The great majority of bacteria possess greater or less power of producing one or more of the organic acids from glucose, although much work has yet to be done in determining the kinds of acids produced by different species. The following table shows the products of the fermentation of glucose by a number of common bacteria:

Bacillus acidi-lactici—acetic and lactic acids, traces of alcohol and gas.

Bacillus aerogenes—acetic, lactic and succinic acids, alcohol, carbon dioxide and hydrogen.

Bacillus typhosus—lactic acid.

Bacillus coli—acetic, formic and lactic acids.

Bacillus prodigiosus—formic and succinic acids.

Bacillus butyricus Botkin—acetic, butyric, formic, propionic, lactic, and succinic acids; butyl and ethyl alcohol, carbon dioxide and hydrogen.

Bacillus amylozyma Perdrix—acetic and butyric acids, carbon dioxide and hydrogen.

Cholera Micospira—lactic acid.

Micrococcus pyogenes—lactic and valerianic acids.

Streptococcus pyogenes—lactic and volatile organic acids.

The organic acids produced by the fermentation of glucose tend to combine with any free base in the soil such as lime, soda, potash, and, in a measure, to decompose carbonates. But where this base is not present in sufficient quantity the free acids accumulate and the soil becomes sour. Under active cultivation, however, the acids and their salts undergo a still further fermentation whereby they are converted into carbon dioxide and marsh gas (CH_4).

Thus cultivation has a tendency to overcome acidity by stimulating the growth of those bacteria which destroy organic acids.

(d) *The Action of Oxidizing Enzymes in the Fermentation of Vegetable Matter.*

It is a common phenomenon that where grass or green hay is made into a pile the interior will begin to ferment, and with this there will be a considerable rise of temperature. A similar process goes on in the manure heap, and another when green fodder is packed in the silo.

In the silo the temperature in the center of the fermenting mass may rise as high as 150 degrees F. With this fermentation there is a considerable loss of organic matter which may vary from 4 to 40 per cent. The temperature as well as the loss of material in the silo is dependent upon the amount of air, or more properly the oxygen present, and this depends upon the looseness or density of the packing. The change is manifestly one of combustion due to the absorption of oxygen, and the products of this change are the same as those evolved in any other combustive process, i. e., carbon dioxide and water. Furthermore, the amount of carbon dioxide evolved is a measure of the degree of combustion and of the organic matter consumed, as well as of the heat produced.

Formerly it was supposed that the fermentation of silage was due to the agency of bacteria, but now it is believed to be simply an expression of the vital energies of the plant cells. All vital energy manifests itself in the production of heat; this heat is the result of oxidation, or the actual burning or destruction of a portion of the vital substance. Yeast when massed into a heap shows a rise of temperature due to its vital energies. This rise takes place only in the presence of oxygen or air, and in a vacuum no such increase of temperature occurs. The germination of seed is accompanied by a rise of temperature, and oxygen is necessary to the process.

The animal body gives off heat and the air we breathe is the draught for this ever consuming fire within, while the carbon dioxide exhaled is a measure of the rapidity of this combustion process.

In a similar manner plants evolve heat and their substance is, in a measure, oxidized or burned to supply this heat, a portion of which is converted into the vital energies of the plant.

Respiration is the breathing-in of air and the breathing-out of the gaseous products of combustion. This takes place in both animals and plants, and heat is the result. Hence when green vegetable matter composed of living cells is massed together these processes of respiration will continue for a time, and heat is the result. When such matter is massed together the heat evolved can not readily escape, and a considerable elevation of temperature is the result.

But the question may be asked, what causes the oxygen of the air to combine with the elements of organic matter whereby this combustion is affected. Under ordinary conditions oxygen has no affinity for organic carbon. Something must be present to stimulate this combination.

We have already found how water is made to combine with certain organic compounds through the agency of special enzymes, so in accordance with this it has recently been shown that a number of oxydation processes can be effected through the agency of another class of enzymes known as *oxydases.*

It has been already noted that yeast when in mass developes a rise of temperature, and it has generally been assumed that this is due to the respiratory activities of the cells, but it has recently been shown that there can be extracted from the yeast cells, independent of the cells themselves, a substance which has the power of oxidizing glycogen with a perceptible increase of temperature.

Thus it appears not to be the vital protoplasm of the cell but some substance which can be extracted therefrom which possesses the power of oxidizing organic matter with the production of heat. This active substance is an oxidizing enzyme.

It is now quite generally believed that oxidizing enzymes are quite generally distributed throughout vegetable tissues, and that they occur dissolved within the fluids of the cells.

In the presence of oxygen they cause a union of the latter with carbon, carbon dioxide being evolved. Thus it may be considered at least a working hypothesis that all processes of respiration are associated with the activities of oxidizing enzymes.

When green fodder is cut and placed in the silo, cells previously protected from the air are exposed, and the combined action of the air and the liberated oxidizing enzymes results in a rapid oxidation with loss of substance.

When fruits are cut open their exposed surfaces turn dark, due to the combined action of contained oxidizing enzymes and the atmosphere.

Besides the ordinary gaseous products of oxidation, it has been shown that oxidizing enzymes may produce certain by-products, notably the organic acids. Thus ensilage may become sour without a trace of bacterial fermentation.

Fresh olives when placed in heaps ferment. With this there is an increase of temperature, a liberation of carbon dioxide, and the formation of acetic and other fatty acids. Talomei shows this fermentation to be due to a special oxidizing enzyme which he called *olease.*

When green crops are plowed under their tissues continue to undergo an oxidation or respiratory process similar to that which

takes place in silage. The carbohydrates are mainly attacked with a certain loss of substance, the evolution of carbon dioxide and probably the production of organic acids. This process, however, does not continue long but is succeeded by the ordinary bacterial fermentation already stated.

5. The Decomposition of Proteid Matter.

Proteid matter is a valuable source of plant food because of its contained nitrogen. This nitrogen before it can be easily assimilated by the plant must be converted into the condition of nitrate. The stages leading up to the production of nitrates are:

1st. Putrefaction or the conversion of proteid matter into ammonia (ammonification).

2d. The oxydation of ammonia to nitrites, the first stage of nitrification, and,

3d. The oxidation of nitrites to nitrates, the final stage of nitrification.

These processes will be considered in turn.

(*a*) *Putrefaction and Ammonification.*

Liebig[23] and the older investigators considered putrefaction a chemical process, the final products of which were carbon dioxide, water and ammonia.

In 1837 v. Schwann made the important discovery that fermentation and putrefaction germs were invariably found in the atmosphere, and it was left to Pasteur and his co-laborers to demonstrate finally that putrefaction was due to the agency of micro-organisms.

Since the early discoveries of Pasteur it has been shown that a great variety af bacteria found in soil, water and organically polluted fluids are capable of effecting the decomposition of albuminous or proteid matter.

The first step in the change is the conversion of insoluble proteids into soluble peptones, a process similar to that which takes place in the stomach. The liquefaction, or as it is called, the peptonization of proteids is effected through the ability of the bacteria to secrete an enzyme of the nature of animal *trypsin*. All bacteria which liquefy gelatin have peptonizing properties to a greater or less degree, and hence the power of converting proteids into peptones. Liquefying bacteria are abundantly present in all soils, hence the vital agencies are there at work which cause a rapid peptonization of all proteid bodies.

The next step in the process is the conversion of peptones into amido-acids and basic amines.

The following is a list, after Rideal,[24] of the amido acids which have been found as products of the putrefaction of proteids:

Name.	Constitution.	Formula.	Products of Further Decomposition.
Glycocin, ...	Amido-acetic, ...	$CH_2 (NH_2) COOH$,	Ammonia and acetic acid.
Leucin, ...	Amido-isocaproic,..	$\left\{\begin{array}{l} C_5H_{10}NH_2, \\ COOH, \end{array}\right\}$	Ammonia and isocaproic acid.
Tyrosin, ...	B-oxyphenol-amido propionic.	$\left\{\begin{array}{l} CH_2C_6H_4(OH), \\ CH_2(NH_2)\ COOH \end{array}\right\}$	Indol, phenol and skatol.
Aspartic, ...	Amido-succinic, ...	$\left\{\begin{array}{l} CH_2COOH, \\ CH\ (NH_2)\ COOH \end{array}\right\}$	Ammonia and malic acid, then succinic.
Asparagin, .	Amido-succinamic,.	$\left\{\begin{array}{l} CH_2CO(NH_2), \\ CH\ (NH_2)\ COOH \end{array}\right\}$	Ammonia and malic acid, then succinic.
Glutamic, ..	....	$\left\{\begin{array}{l} C_3H_5(NH_2), \\ COOH, \end{array}\right\}$	Ammonia and probably succinic acid.

The amido acids are next decomposed into ammonia and organic acids as shown in the last column of the above table. Tyrosin breaks into indol, phenol and skatol.

Of the basic products of putrefaction we have non-volatile bases known as ptomaines and leucomaines, produced in minute quantities, and certain volatile bases such as monomethylamine and trimethylamine. These latter basic products by further decomposition are converted into ammonia.

From the preceding it is seen that the final products of putrefactive fermentation are ammonia and organic acids. Naturally the organic acids will combine with the ammonia to form salts, but these salts will undergo a still further change in which the acid is converted into carbon dioxide, hydrogen and marsh gas. The two latter escape while the carbon dioxide combines with the ammonia to form carbonate of ammonia. This completes the process, the proteid matter resolving itself into two gases, hydrogen and marsh gas, with a solid residium in the form of ammonium carbonate.

Theoretically this is true, but in reality there remains as a "by-product" of these reactions, as Rideal puts it, "a varying but small quantity of dark pulverent matter resembling the humus or peaty substances of soil."

In addition to this it is known that under certain conditions of exclusion of air, and of the development of the more strongly anaerobic bacteria, a certain amount of the nitrogen escapes in the free state before it is converted into ammonia. While this takes place in putrefying fluids such as sewage it probably does not occur to any appreciable degree in soils.

According to Sommaruga, aerobic bacteria growing in non-saccharine nutrient media always form an alkali from albuminous bodies. These alkaline bodies so far as known are either ammonia

or amides, which in part become converted into ammonia. Thus it may be said that ammonia production is almost a universal function of bacteria.

In the following table is shown the production of ammonia by several common species of soil bacteria grown in beef broth at room temperature:

Table III.

	Milligrams of NH_3 per 100 c. c. of Culture produced in			Percentage of the total nitrogen in the medium converted into ammonia in 30 days.
	Seven days.	Fourteen days.	Thirty days.	
Bacterium mycoides,	9.18	20.06	45.50	21.0
Bacillus subtilis,	6.46	18.35	46.20	21.4
Bacillus pulvinatus—				
Variety A,	1.02	10.20	....	....
Variety B,	....	5.78	18.30	8.4
Bacillus No. 6,	0.30	5.44	22.00	10.2
Bacillus No. 7,	2.40	19.72	38.10	17.6
Microspira tenuis,	....	....	....	....
Bacterium fermentationis,	0.30	8.50	27.90	12.9

In the above table it is seen that the highest quantity of ammonia was produced by *Bacterium mycoides* and *Bacillus subtilis*, the latter organism converting 24.4 per cent. of the total nitrogen of the medium into ammonia in thirty days. Both of these species are abundantly and constantly present in soils, and are important factors in the ammonification of organic matter.

It is also noted that there is a marked difference in the ability of the different species studied to produce ammonia, and in the rate of its development; one form *Microspira tenuis* producing none after a period of thirty days. Complete absence of ammonia production is however the exception.

(*b.*) *Nitrification.*

The subject of nitrification is one which has received a large share of attention from scientific men, and the literature thereon is very voluminous, extending over a period of twenty-five years.

In 1871-75, Sir J. H. Gilbert found that the drainage waters from

the experimental fields of Rothamsted contained more nitrates as the amount of ammonium salts applied to the soil increased.

In 1878 Messrs. Schlösing and Müntz[25] laid before the French Academy the results of an experiment tending to prove that nitrification was due to the action of an organized ferment. A glass tube one meter long was filled with ignited quartz sand and powdered limestone. Through this sewage was passed at intervals. During the first twenty days the sewage which passed the filter remained unaltered, after which nitric acid began to appear until the filtrate no longer contained any ammonium salt, but only nitrates. Thus it was shown that active nitrification was going on within the body of the filter, and it was suspected that micro-organisms so abundantly present in the same were the active agents of the change.

To demonstrate this point, chloroform vapor, a well-known germicide, was passed through the filter; as a result it was found that ten days after the introduction of the vapor all nitrates had disappeared, and the sewage passed through unchanged. In other words, the chloroform vapor had so paralyzed the micro-organisms present as to completely check the process of nitrification.

Messrs. Schlösing and Müntz were, however, unable to isolate any specific ferment capable of inducing nitrification, and nothing was accomplished toward this end until the year 1886. Celli-Zucco[26] and Heraeus[27] at this time succeeded in isolating from water rich in nitrates a number of forms of bacteria, which, however, only possessed very feeble nitrifying properties.

Frank[28] simultaneously with the latter attempted a similar isolation of the nitrifying organism, but without result, and concluded that nitrification was not due to the direct action of bacteria, but that it was a purely chemical process. This view was opposed by a number of writers, notably, Landolt, Platt and Baumann.[29]

In 1888-89 Warrington[30] and also Frankland[31] studied a large number of soil bacteria, but neither was able to find one which produced any thing approaching active nitrification. Frankland maintained, however, that the nitrifying organism was present, but had not been isolated.

In 1890 Frankland[32] succeeded in cultivating a spherical (coccoid) organism about 0.8 micromillimeters in diameter, which possessed the power of converting ammonium salts into nitrous, but not into nitric acid. The separation was by means of the dilution method in media containing only inorganic salts. In this the form in question grew most successfully.

This fact, and other points in the investigation of Frankland, at once revealed the important principle that the organism of nitrification does not grow normally in media rich in organic matter, and that, therefore, the ordinary method of separation by means of

gelatin plates was inapplicable for the isolation of the specific nitrifying agent.

In the same year an identical principle was discovered and put into practice by Winogradsky[33] who succeeded in separating the nitrifying ferment by using a purely inorganic medium containing:

Water of Lake Zurich,	1000 cc.
Ammonium sulphate,	1 grm.
Potassium phosphate,	1 grm.
Basic carbonate of magnesia,	an excess.

In this solution nitrification became very active, when previously inoculated with a small quantity of soil.

By a long series of fractional cultures one was finally obtained which contained but few bacteria except the nitrifying organism. From this somewhat impure culture, gelatin plates were made. On the principle that the foreign non-nitrifying organisms grow in gelatin while the nitrifying bacteria do not, an indirect method of isolation was utilized.

In the portions of the gelatin between the colonies of non-nitrifying bacteria the nitrifying organisms would be liable to be present in a pure state, but unable to produce colonies because of uncongenial soil. By removing bits of this apparently sterile gelatin a few nitrifying organisms, unmixed with others could be transferred to a favorable solution like the one already given. In this way Winogradsky was able to isolate the nitrifying organism.

Later, in 1891, Warrington.[34] in a solution containing mineral salts, obtained, after repeated generation, a culture which nitrified vigorously, and which, by containing no organism which would grow on gelatin, was regarded by him as containing only nitrifying bacteria. The germ thus obtained was an oval form seldom one micromillimeter thick and scarcely longer than broad.

At this time Winogradsky[35] made a decided improvement in the separation of the nitrifying organism from solutions containing it by the use of the Kühne gelatin silica medium.[36] The nutrient basis of this medium as used by Wirogradsky was composed of: ammonium sulphate, 0.41 gram, magnesium sulphate, 0.05 grm., potassium phosphate, 0.10 grm., sodium carbonate, 0.6-0.9 grm., calcium chloride a trace, and water 100 cc.

The inoculation of the plates took place either by mixing the inoculating material with the above solution before the addition of gelatinous silica, or it was made as a streak or smear culture on the already hardened material. In this way the nitrifying organisms developed distinct colonies from which pure cultures were made.

The investigations of Winogradsky and simultaneously of Warrington showed:

1. That in the soil the nitrifying process was effected by two distinct but closely related organisms; the one converting ammonia into nitrous acid and nitrate, and the other changing the nitrites into nitrates.

2. That these two processes follow one another in such rapid succession that the production of nitrites is only a transitory phenomenon, so that if both the nitrite and nitrate organism be added to sterilized soil the process is completed in the natural way, only the merest traces of nitrous acid appearing.

The nitrate organism of Winogradsky is an oval form about 0.5 micromillimetres in length. The nitrite germ varies from oval to spherical and is about twice the size of the former. See Figs. 5 and 6.

If to a mineral solution containing ammonium salts, a pure culture of nitrite ferment be added, only nitrites will be formed, and these will remain unchanged in the absence of the second nitric ferment. If, however, the two organisms be added simultaneously, nitrates will be rapidly formed.

In 1892, Winogradsky[37] studied the nitrifying organisms of soil, from a number of different localities. Those from several parts of Europe, from Africa, and from Japan, which he considers to be the same organism, he names *Nitromonas europea;* a second form from Java soil, differing from the first he names *N. javenensis.* Both of these comprise the nitrite ferments of Winogradsky; the second nitrate ferment was isolated by Winogradsky from Quito soil and differs from the first not only as to size, as above mentioned, but also by entirely lacking the motility common to the latter.

The notable researches of Winogradsky have been followed by others which have interest from a controversial standpoint.

In 1895 Burri and Stutzer[38] isolated from soil a nitrate organism with properties akin to the Quito bacillus of Winogradsky. It was a motile organism, 0.75-1.5x0.5 micromillimeters, growing on silica plates in definite colonies, but also possessing the power to grow on gelatin and to liquefy the medium; said organism according to the writer being able to convert nitrites into nitrates, but losing such power when grown on organic media.

The above results of Burri and Stutzer, so contrary to those of Winogradsky, brought forth a vigorous rejoinder from the latter. In this Winogradsky stated that he tested the same earth used by Burri and Stutzer and isolated therefrom his own Nitromonas, and that the latter when tested in bouillon, meat pepton, gelatin and agar failed to grow. He therefore regards the German work as erroneous.

In 1897 Stutzer and Hartleb[40] appeared with a still more startling series of discoveries in which they not only maintained the ability of the nitrifying organisms to grow in organic media, but also showed

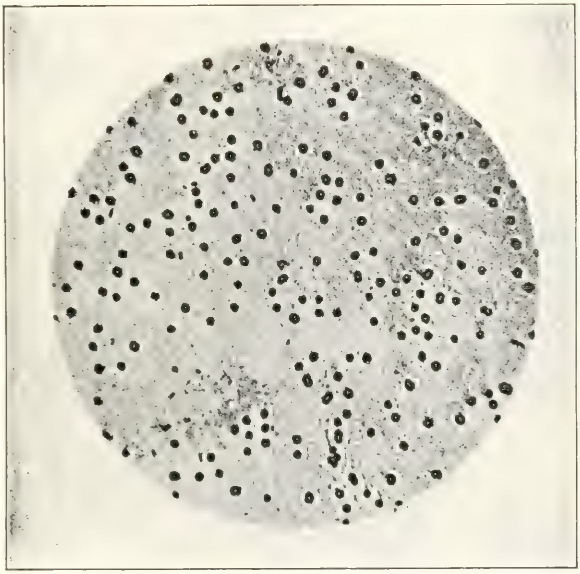

FIG. 5.—The Nitrite Organism of Winogradsky, isolated from Quito earth. Converts ammonium salts into nitrites, the first stage of nitrification. (After Winogradsky: Ann de l' Institut Pasteur, 1891, Plate XVIII.)

Fig 6.—The Nitrate Organism of Winogradsky, isolated from Quito earth. Converts nitrites into nitrates—the second stage of nitrification. (After Winogradsky: Ann. de l' Institut Pasteur, 1891, Plate XVIII.)

that the latter possessed a polymorphic habit never before imagined in this or any other like group in the whole domain of mycology. The ability of simple coccoid or rod-shaped forms to develop into filaments or even into branched forms, with the further production of true gonidia and other even more highly organized fructification bodies, is a species of morphological transcendentalism likely to cause skepticism.

I will not enter into the details of Stutzer and Hartleb's investigations, as I think we should await further researches before giving them credence. It is easy to believe that the latter's culture, which they claimed to be those of the organism of nitrification, were in reality impure, and that in the variable forms described by them they were in reality dealing with several distinct organisms instead of one.

That this seems true is indicated by the investigations of Gärtner[41] and Fräenkel[42] during the present year.

Gärtner discusses the work of Burri, Stutzer and Hartleb on the polymorphism of the nitrifying organism, and from presumably pure cultures of the latter's nitrifying ferment was able to isolate thirteen different micro-organisms, including a fungus form (Schimmelpilz); thus proving their impure character. Furthermore, Gärtner showed that these several organisms, when once separated in their pure state, retained their fixed character, with no tendency to polymorphism, and indicated none of those transition stages from bacteria to fungi noted by Stutzer. Again none of these isolated organisms possessed the power to convert ammonia into nitrites. C. Fraenkel simultaneously isolated from Burri and Stutzer's cultures 11 different organisms, including 7 bacilli, 2 streptothrices and 2 fungi (a Fadenpilz and a Schimmelpilz). These showed no polymorphism, but all retained constant characters.

From what has been written there is reason to believe:

1. That nitrification in the soil is caused by a distinct or rather by two distinct organisms possessing certain definite characters.

2. That these organisms will not grow in the presence of any considerable amount of organic matter, and that all reported attempts to cultivate them on ordinary organic media are without authentication.

3. That the above nitrifying organisms are found abundantly in all cultivated soils, and that in ordinary soil water containing, besides mineral salts, a due proportion of ammonium carbonate, sulphate, etc., they find a favorable medium for their development.

4. That the result of such development is: (a) The conversion of ammonia into nitrous acids through the agency of the nitrous organism; and (b), the immediate conversion of the previous nitrous into nitric acid by means of the equally abundant nitric ferment.

Understanding, therefore, that these two stages of nitrification are

due to definite organisms in the soil, the laws which control nitrification are simply the laws which control the life and development of said organisms.

If a soil be wet with a one per mille solution of bichloride of mercury, no nitrification can take place; firstly, because the mercury compound has destroyed the life of all nitrifying as well as other organisms, and secondly, because the presence of such a salt in the soil will prohibit the development of all nitrifying ferments which come after.

Again, if a soil be heated above a certain temperature, all nitrifying ferments will be destroyed and nitrification will cease.

Chloroform, formaldehyde gas, sulphurous acid gas, etc., passed through a layer of soil will, on the same principle, prevent further nitrification.

These, however, are all agencies implying the total destruction of the nitrifying ferments. In addition to these there are certain conditions which, while they do not annihilate the life of the nitrifying organism, are yet either favorable or unfavorable to their normal development. These conditions the agriculturist must understand, in order to control the nitrifying process in the soil.

(c.) *Conditions Affecting Nitrification.*

Quantity of Organic Matter or Humus in the Soil.

It has already been stated that the nitrifying organism will not grow in a medium containing any considerable amount of soluble organic matter.

When sewage is applied to land nitrification cannot, therefore, begin until after the ordinary putrefying and ammonifying bacteria have decomposed much of the organic matter and rendered the soil water a fit pabulum for the development of nitrifying ferments.

In a 12 per cent. solution of urine, according to Warrington,[43] nitrification did not begin until about ninety days, and then only after 447 milligrams of ammonia per litre had been produced by the decomposition of the organic matter present.

For this reason sewage when applied to land should be used cautiously and not too frequently, otherwise the soil will become so rich in soluble organic matter as to hinder nitrification and thus render the large accessions of nitrogenous food useless.

Thus a soil too rich in humus is an unfavorable nitrifying ground up to the limit when nitrification ceases. Just what this limit is, is as yet unknown. Wiley[44] mentions a soil from Florida containing over 80 per cent. of organic matter, and less than 10 per cent. of sand and other mineral matter, which was found to be entirely free from nitri-

fying ferments. In ordinary arable land, however, the quantity of organic matter, or humus, never reaches a height sufficient to interfere with the process of nitrification, and hence only in rare exceptions does this factor enter into the question of nitrification.

Aeration and Cultivation.

The nitrifying ferments are what are technically called aerobic, that is, they grow only in the presence of atmospheric air.

Schlösing[45] has determined the rate of nitrification in a moist soil in an atmosphere containing various proportions of oxygen as follows:

1. When oxygen was entirely absent there was a reduction of nitrates and an evolution of free nitrogen.
2. With 1.5 per cent. of oxygen nitrification was marked.
3. With 6 per cent. of oxygen the quantity of nitrate produced was more than double the above (2).
4. With 16-24 per cent. of oxygen the quantity of nitrate produced was more than four times that in (2).

The effect of stirring and pulverizing the soil upon the growth of crops has long been known, and long before the philosophy of the operation itself was in any wise understood.

Among other reasons why cultivation is beneficial is the fact that it aids nitrification by bringing the oxygen of the air into more immediate contact with the nitrifying ferments. The effect of stirring and pulverizing the soil is well shown in an experiment by Deheraine.[46]

Six pots filled with soil, which had remained undisturbed for two years, were selected. Three of the pots had their soil emptied on a clean floor in separate piles, and each lot was kept stirred and pulverized from time to time for a period of six weeks. In three of the pots the soil remained untouched. At the end of the period the nitrates in the several soils were determined, when it was found that the average percentage of nitrates in the three stirred and pulverized soils was 23.7 times that found in the soils which had remained undisturbed in the pots. While it is not presumed that ordinary farm cultivation will produce as marked results as the preceding experiments indicate, it is,nevertheless, clear that the effect of cultivation is to markedly increase nitrification, and in a ratio proportionate to its thoroughness and frequency.

In this principle we have the explanation of why the late cultivation of orchards is inadvisable. Nitrification is more active in autumn than at any other time. This activity would be increased enormously by cultivation, resulting in the production of large

stores of nitrates, the bulk of which would be washed out of the soil by the winter and early spring precipitation.

The Presence of Moisture.

Bacteria of all kinds, including the nitrifying organisms, grow only in the presence of moisture. Soil waters, containing dissolved mineral salts and ammonium compounds, are, therefore, the natural media in which the nitrifying ferments develop.

In a dry soil nitrification cannot take place; hence in periods of drouth, where the superficial layers of the soil for a depth of several inches become dry, nitrification is suspended. On the other hand, excess of water prevents nitrification by excluding air, hence water-logged soils must first be drained before they become proper nitrifying beds. In a wet soil not only is nitrification inactive or entirely suspended, but the opposite process of denitrification takes place with the loss of nitrogen in the free gaseous condition.

A soil may be in good condition in its superficial layers, but have an impervious clayey subsoil, which retains the downward drainage; or a still deeper layer of clay may raise the level of ground water so near the surface as to render the subsoil wet. In either case the deeper zones of the soil become too damp for active nitrification, so that this process instead of being carried on from the surface to a depth of about 27-36 inches is confined to a more superficial zone; the elaboration of much valuable plant food is thereby prevented.

The functions of underdrains is thus not only to withdraw the excess of subsoil water, but also by the downward movement of the same to draw air into the soil and thus supply oxygen to the nitrifying ferments.

The Reaction of the Soil.

Nitrification can only take place in a feebly alkaline medium, but the presence of anything beyond a small quantity of an alkaline salt is a hinderance to the process, while a large amount will check it entirely. Thus Warrington[47] showed that the presence of 0.032 per cent. of bicarbonate of soda distinctly retarded nitrification, and that with the presence of 0.096 per cent. nitrification was only barely possible. The same author also showed that the presence of 0.0447 per cent. of ammonia in urine rendered it unnitrifiable. Dumont[48] and Crochetelle showed that carbonate of potash added to soil at the rate of from 1 to 2.5 grams per 1000 grams of soil markedly increased nitrification, but that large applications of the salt progressively diminished the rate of nitrification, and that the addition of 8 grams per 1000 grams of soil completely checked it.

A heavy dose of lime by unduly increasing the alkalinity of the

soil may at first check or suspend nitrification until the said lime has been converted into carbonate. This, however, takes place rapidly, diminishing in turn its strong alkaline properties and permitting nitrification to commence more actively than before.

Equally unfavorable to nitrification is an acid condition of the soil. The extreme susceptibility of the nitrifying organism to acid is shown by the researches of Wiley and Ewell.[49] In the experiments of the latter, solutions containing calcium chloride and water were seeded with soil, containing of course nitrifying bacteria. In this medium nitrification continued until the medium reached an acidity equivalent to 4 c. c. of normal acid per 100.

It is a well known fact that nitrification has practically ceased in forest and woodland soils. The same is true, but to a lesser degree, in the soil of old pastures. That such cessation of nitrification is not due to the absence of nitrifying bacteria is shown by the fact that such soils begin to nitrify rapidly upon the addition of some base which overcomes the acidity.

In the experiment of Dumont and Crochetelle, already referred to, a soil which had been in grass from time immemorial and contained 6.84 per cent. of humus was treated with variable amounts of carbonate of potash. It was stirred and watered several times during the experiment. After one month the nitrates were extracted with the following results: Nitric nitrogen, per 1000 grams of soil, without addition of carbonate of potash, 70 mg; with 1 gram of carbonate of potash per 1000 grams of soil, 160 mg; with 2 grams of carbonate of potash, 230 grams; with 3 grams, 250 mg; with 4 grams, 130 mg; with 5 grams, 73 mg.

In an experiment with marsh land containing 5.76 per cent. of humus similar results were obtained, showing that while in the original soil nitrification was practically *nil*, the addition of carbonate of potash resulted in active nitrification.

Too great a degree of alkalinity, as has been already seen retards or entirely checks nitrification.

In a too concentrated solution of urine, the nitrifying process is hindered after a certain time by the accumulation of ammonium carbonate which is being produced by the ammonifying bacteria at a more rapid rate than the oxidation of the ammonia to nitric acid. This is the condition of most stable manures in bulk or before they become intimately mixed through the soil.

The addition of lime to stable manure in a state of ammoniacal fermentation would only still further hinder their nitrification by increasing alkalinity, and would also drive off much valuable ammonia. Lime added to fresh manure before ammonium carbonate has been produced will not cause the above loss of free ammonia,

but it will hasten the ammoniacal fermentation so rapidly that nitrification will soon cease.

Both ammonification and nitrification can be made active in a manure heap, when not too closely compacted, or in a soil freshly and heavily dressed with manure, by the use of plaster. Plaster acts by decomposing the excess of ammonium carbonate as fast as formed, producing in turn non-volatile ammonium sulphate, and calcium carbonate (chalk); the latter compound serving as a mild base whose presence is favorable to nitrification.

The loss of ammonia from manure piles is not considerable as long as the latter are kept moist or well compacted. When manure becomes dry, or when the latter is forked over or otherwise kept too loose, a considerable loss of ammonia will result. So far as the loss of ammonia alone is concerned, the application of plaster may not be necessary, but if the latter be spread over the pile with each considerable addition of manure from the stable, its presence will materially aid in the ammonification and nitrification of the same and make it a more active stimulant when applied to the land.

Temperature of the Soil.

Experience at Rothamsted in England shows that nitrification takes place quite freely in the soil during an ordinary English winter. Warington[50] in one series of laboratory experiments showed a considerable rate of nitrification in solutions kept at the temperature of 37 and 39 degrees F.

According to Schlösing and Müntz, nitrification becomes active at 54 degrees F. and rapidly increases up to 99 degrees F., at which point it is nearly ten times as rapid as at 54 degrees. Above 99 degrees the rate of nitrification rapidly diminishes; at 122 degrees F., very little nitrate is produced, and at 131 degrees F., it ceases entirely.

The Physical Condition of the Soil.

Schlösing has shown that nitrification and microbic combustion in general are less active in fine-grained compact soils than in lighter coarse-grained soils.

A certain proportion of clay and sand appears to be most favorable for a maximum rate of oxidation. In the experiment of Schlösing equal amounts of ammonium sulphate were applied to equal quantities of artificial soil in pots, and the nitrates determined at the end of certain periods; from this the percentage of the ammonium salt which was converted into nitric acid was determined as given in the following table:

Table IV.

	Composition of Soil.		
	Sand.	Clay.	Percentage of the ammonium salt nitrified at 26°-27° C. after 72 days.
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

*Percentage of ammonium salt nitrified after 106 days, temperature of laboratory.

From this table it is seen that the maximum rate of nitrification took place in the soil with a proportion of clay varying from 10-20 per cent. with from 80-90 per cent. of sand respectively, the rate diminishing as it is either lighter or heavier than the above mean. Nitrification, other things being equal, is, therefore, most active in soils which are neither too light nor too heavy.

The soil best meeting these conditions are the sandy loams which occupy an intermediate position between the heavy grass lands of the inner margin of the costal plain and the light truck lands of the seaboard. One way in which soil texture affects rate of nitrification is by its effect on available water.

The finer particles of heavy soils have such a strong attraction for water that a large part of the soil moisture is rendered unavailable for the use of the nitric ferment.

(d.) The Rate of Nitrification in the Soil.

When samples of soil are taken and kept loosened and stirred, and under favorable conditions of temperature and moisture, the rates of nitrification therein are exceedingly high, as shown by the following Table V[11] from experiments by Lawes and Gilbert:

Table V.

Source of Soil.	Parts of nitric nitrogen produced per day per million parts of air-dry soil.	Period of experiment in days.
Rothamsted soil, first 9 inches,	0.588	119
Do. with ammonium chloride added,	0.944	119
Manitoba soils, Lawes and Gilbert,	0.700	235
Soil, Dehérain,	0.76-1.09	90

The large quantities of nitrates produced in the rich Manitoba soils is due to the relatively large amounts of humus which they contain; the figures for the Rothamsted soil in the same table will, therefore, represent a more normal and average condition.

More detailed figures regarding rates of nitrification are given in Table VI[51] for one of the poorest of the Manitoba soils.

Table VI.

Depths—Inches.	Nitrogen as Nitric Acid Produced per Day During Different Periods of Exposure, in Pounds, Per Acre. Periods of Exposure.						Total nitrogen produced in 285 days.	Total nitrogen per acre in original soil.	Percentage of nitrogen converted into nitric acid in 285 days.
	1st.	2d.	3d.	4th.	5th & 6th.	7th.			
1-12,	0.92	0.88	1.08	1.00	0.36	0.69	227.	5,236	4.78
13-24,	0.17	0.12	0.12	0.52	0.16	0.27	57.2	3,488	1.64
25-36,	0.58	0.49	0.03	0.18	0.03	0.03	43.8	2,592	2.07
37-48,	0.08	0.04	0.01	0.01	0.02	0.02	7.6	870	1.22
							335.6	12,186	

The preceding table shows:

1. That the greater proportion of the nitrates, nearly 65 per cent., are produced in samples from the first 12 inches of soil; both because of the greater quantity of humus in the surface layer and perhaps also because of the greater vigor of the nitrifying ferments in this same zone.

2. That in zones between 12 and 36 inches below the surface large quantities of nitrates can be found, 30 per cent. of the whole, pro-

vided samples from this depth are brought under conditions favorable for nitrification.

3. That at depths greater than 36 inches the proportion of nitrates which can be found is small.

The large quantities of nitrates produced in 285 days, calculated as 335 pounds per acre, in terms of nitric nitrogen, show that our soils when brought under the most favorable conditions for nitrification can be made to produce nitrates at a rate far in excess of the needs of the most exacting crops.

Again, the small proportion of nitrogen converted into nitric acid in a single year, as compared with the total nitrogen of the soil, as shown in the last column of Table VI, demonstrates, furthermore, that virgin soil will at least become abundant sources of nitrogen to growing crops for scores of years.

The question of nitrogen supply in even ordinary soils becomes, therefore, a question of controlling nitrification and of conserving the supplies of nitrates produced by nature. It is not to be supposed, however, that anything like the supplies of nitrates obtained in the preceding experiments can be realized by ordinary tillage to the depths indicated. The production of an amount of nitric nitrogen in any wise approaching 335 pounds to the acre is, therefore, not to be expected. Were it so nature would be most wasteful in her operations, a charge which can never be truthfully brought against her.

A crop of wheat at the rate of 15 bushels of grain per acre will require something like 24 pounds of nitrogen; therefore to produce normal crops the economy of nature would demand that amounts of nitric nitrogen comparable to the actual needs of crops should be produced. This would be true to an approximate degree, provided the roots had complete possession of the land, down to the lower limits of nitrification, and also provided such crops had possession of the land during every month of the year.

In the case of wheat for instance, neither condition holds and consequently the crop being unable at all times to utilize nitrates as fast as they are produced, there must needs be considerable loss.

The fact that the drainage waters from unmanured wheat fields show an amount of nitric nitrogen approximately equal to that used by the crop is an indication that there is produced in the soil each year a stock of nitrates more than double in quantity that which the crop itself can utilize.

The relation between the quantity of nitrogen removed by a crop and that present in the drainage water is brought out in the following Table VII by Lawes and Gilbert. The figures show (1) the number of pounds of nitrogen per acre in crop and in drainage water;

(2) the number of parts of nitrogen in crop and in drainage compared with 100 parts in the manure. These last figures are given in black-faced type. The figures in the last column give the amounts of nitrogen unaccounted for, the plus sign indicating a gain of nitrogen and the minus sign a loss of nitrogen over that contained in the manure.

Table VII.

Plot.	Character of Manuring.	Nitrogen in Manures.	Nitrogen in Crop.	Nitrogen in Drainage.	Nitrogen Unaccounted for.
3 and 4,	Manured continuously,	0 lbs. per acre,	12 lbs. per acre,	15 lbs. per acre,	+27 lbs. per acre.
		0 per cent.,	**45.5** per cent.,	**55.5** per cent.,	**+100** per cent.
16,	Unmanured since 1865-1882,	0 lbs. per acre,	14 lbs. per acre,	16 lbs. per acre,	+30 lbs. per acre.
		0 per cent.,	**46.6** per cent.,	**53.3** per cent.,	**+100** per cent.
5,	Mixed mineral manures,	0 lbs. per acre,	16 lbs. per acre,	17 lbs. per acre,	+33 lbs. per acre.
		0 per cent.,	**48.5** per cent.,	**51.5** per cent.,	**+100** per cent.
6,	Mixed +200 lbs. ammonium salts,	44 lbs. per acre,	27 lbs. per acre,	22 lbs. per acre,	+5 lbs. per acre.
		100 per cent.,	**61.3** per cent.,	**50.0** per cent.,	**+11.3** per cent.
7,	Mixed +400 lbs. ammonium salts,	88 lbs. per acre,	40 lbs. per acre,	28 lbs. per acre,	—20 lbs. per acre.
		100 per cent.,	**45.4** per cent.,	**31.8** per cent.,	**—22.8** per cent.
8,	Mixed +600 lbs. ammonium salts,	132 lbs. per acre,	49 lbs. per acre,	43 lbs. per acre,	—40 lbs. per acre.
		100 per cent.,	**37.1** per cent.,	**32.5** per cent.,	**—30.4** per cent.
9,	Mixed +550 lbs. nitrate of soda,	86 lbs. per acre,	32 lbs. per acre,	58 lbs. per acre,	—30.4 per cent.
		100 per cent.,	**37.2** per cent.,	**67.4** per cent.,	**+46** per cent.
10,	400 lbs. ammonium salts alone,	88 lbs. per acre,	14 lbs. per acre,	50 lbs. per acre,	—24 lbs. per acre.
		100 per cent.,	**15.9** per cent.,	**56.8** per cent.,	**—27.3** per cent.
11,	400 lbs. ammonium salts+super-phosphate,	88 lbs. per acre,	29 lbs. per acre,	39 lbs. per acre,	—20 lbs. per acre.
		100 per cent.,	**32.9** per cent.,	**44.3** per cent.,	**—22.8** per cent.

The preceding table shows from 50 parts of nitrogen in the drainage as compared with 61.3 parts in the crop up to 67 parts in the drainage as compared with 37.2 parts in the crop.

The table also shows that in the case of wheat the greater proportion of the nitrates in the soil are either beyond the reach of the roots, or what is more probable, that they are washed out of the soil at that season, fall or winter, when the wheat has but limited capacity of absorbing them. For this reason wheat is shown to be one of the most exhaustive of all farm crops as regards nitrogen supply. That no such proportionate loss of nitrates occurs with other crops, like grass and clover, which cover the ground especially during the fall and winter months is shown by numerous figures, some of which will be considered under the head of loss of nitrates.

(*e.*) *Losses of Nitrates.*

Relation to Rainfall and Percolation.

Nitrates are easily leached out of the soil and carried into the drainage. In a highly porous, sandy soil free of vegetation, the greater proportion of the annual rainfall, 80 per cent. more or less, will pass downward through the soil and appear as drainage.

In land covered with a sod a much less percentage, about one-third of the rainfall, may pass off as drainage, the remainder being evaporated or thrown off by the plants in transpiration.

In a plot of fallow ground at Rothamsted[52] for a period of 28 years the annual average outflow of drainage was 11.76 inches and the average rainfall for the same period 28.3 inches, making the average percentage of drainage 41.5 per cent. of that of the rainfall.

The action of vegetation in preventing an excessive outflow of drainage is most evident during the months of maximum growth. May to September, as the following figures by Greaves and Evans[52] indicate:

	Rainfall—Inches.	Drainage.	
		Inches; Sand.	Inches; Sod.
January,	2.87	2.73	2.03
February,	1.59	1.52	1.08
March,	1.93	1.60	0.88
April,	1.43	1.12	0.27
May,	2.05	1.65	0.10
June,	2.20	1.57	0.16
July,	1.77	1.21	0.01
August,	2.33	1.78	0.11
September,	2.35	1.74	0.07
October,	2.73	2.40	0.51
November,	2.02	1.96	0.83
December,	2.42	2.17	1.51
Total,	25.7	21.5	7.6

It is evident that the larger the rainfall the greater will be the amount of drainage, and the greater *pari passu* the loss of nitrates. Another factor also governs the amount of nitrates in the drainage, and that is the quantity of nitrogen in the soil, particularly in its soluble form.

The application of considerable quantities of ammonium salts or of nitrates as fertilizers, or of nitrogenous manures as stable manure or rape cake, results in a large increase of nitrates in the drainage. These facts are brought out in the following table from Lawes and Gilbert:

Table VIII.

Nitrogen as Nitrates in Drainage Waters, Broadwalk Field at Different Seasons. Average of three Years in parts Per Million of Drainage Water.

Plot.	Spring sowing to end of May.	June to harvest.	Harvest to autumn sowing.	Autumn sowing to spring sowing.	Whole year.	Nitrogen per acre per inch of drainage.	Character of the Manuring of the Land.
5, ...	2.9	0.2	4.8	5.5	4.2	0.95	Mixed mineral manures.
6, ...	14.7	0.7	6.0	5.4	5.4	1.22	*200 lbs. ammonium salts and minerals.
7, ...	27.1	1.4	7.3	5.4	6.8	1.54	*400 lbs. ammonium salts and minerals.
8, ...	28.2	4.0	13.5	7.5	9.3	2.10	*600 lbs. ammonium salts and minerals.
15, ...	6.7	2.9	7.5	28.1	19.3	4.37	†400 lbs. ammonium salts and minerals.
17, ...	29.7	1.8	6.6	5.5	7.1	1.61	400 lbs. ammonium salts alone.
18, ...	1.5	0.3	5.6	5.5	4.3	0.97	Mixed mineral manure.
2, ...	3.6	1.4	6.0	9.5	7.5	1.70	Barn yard manure.
19, ...	3.7	0.5	7.0	14.0	10.4	2.35	Rape cake.

*Applied in the spring.
†Applied in the fall.

The use of large quantities of ammonium salts, or of nitrate of soda at the time of spring seeding results, as the last table shows, in an immediate increase of nitrates in the drainage waters.

There is every reason to believe that ammonium salts, when applied to the soil, are very rapidly converted into nitrates, and in this form washed out of the soil. The same loss would follow similar applications at the time of autumn sowing as shown by the results from Plot 15, given in the last table.

Hence whenever it becomes necessary to use ammonium salts or nitrates as a crop stimulant, they should be applied in small quantities while the crop is growing. The custom of introducing nitrate of soda with the seed is accordingly a most wasteful operation.

The Amounts of Nitrates Lost in the Drainage.

It is calculated that the River Rhine discharges daily into the ocean 220 tons of nitrates, calculated as nitrate of soda; the Seine 270 tons, and the Nile 1,100[53] tons.

Since the great bulk of this comes from nitrates produced in the soil it is easy to form some idea of the tremendous losses of this the most valuable of all plant nutrients.

From what has already been said it is seen:

1. That given equal rainfall, the amount of nitrates lost in the drainage is greater in sandy than in heavy soils; and in direct ratio to the porosity of the latter.

2. That the loss by drainage, and hence the corresponding loss of

nitrates, is diminished by vegetation; hence in fallow land the loss of nitrates is greater than in land covered with plant growth.

Thus from an unmanured field at Rothamsted, kept fallow and free of weeds, the loss of nitric nitrogen per acre per annum was for three successive years 38.9, 48.3 and 27.4 pounds respectively, while from an experimental wheat field at the same place the similar loss, as an average of 19 years, was in one case 9.1 and in the other 11.9 pounds per acre[52] per annum.

The Effect of Mineral Fertilizers on the Loss of Nitrates and on Nitrification.

I have already mentioned the effect of lime and plaster on nitrification; still another point needs mention.

The nitrifying organism cannot multiply except in the presence, among other elements, of phosphoric acid and potash. Nitrification is, accordingly, aided by applications of mineral fertilizers.

The effect of potash salts alone, or of potash salts mixed with carbonate of lime, in increasing nitrification and ammonification in soils rich in humus, has been shown by Dumont.[54] In soils differently treated the amount of nitric nitrogen produced in 1000 grams of soil in 40 days was in milligrams as follows:

Check,	2.8
Potassium carbonate, 0.1 per cent.,	57.8
Unleached ashes, 0.5 per cent.,	19.0
Muriate of potash, 0.1 per cent., and carbonate of lime, 2 per cent.,	38.0
Muriate of potash, 0.1 per cent., and Thomas slag, 5 per cent.,	41.5
Carbonate of lime, 2 per cent.,	5.3

From the preceding it is seen that a marked increase of nitrates resulted when some form of potash was used. In the mixture of muriate of potash and carbonate of lime, a double reaction between the two took place, producing carbonate of potash and chloride of calcium. The author claims that the action of the potash salts is to combine with the humates of the soil and form a compound which is very readily nitrifiable.

Again, the ability of a crop to utilize the nitrates of the soil is considerably diminished when there is a deficiency of available mineral constituents, especially of potash and phosphoric acid.

The effect of mineral salts upon nitrification and the loss of nitrates is well shown in the following table:[53]

Table IX.

Nitrogen as Nitrates in Soil and Subsoil and in the Drainage Water of Various Plots in the Broadwalk Wheat Field, in Pounds Per Acre.

Plot.	Nitric Nitrogen in the Soil—Pounds Per Acre.				Nitric nitrogen removed by drainage Aug. 30-Jan. 31—lbs. per acre.	Percentage of total nitrogen of soil removed by drainage.	Character of Manuring.
	1st—9 inches.	2d—9 inches.	3d—9 inches.	Total 27 inches.			
2, ...	9.7	5.3	2.8	17.8	11.6	65.1	Unmanured.
5 a, ...	12.6	7.1	4.6	24.3	13.2	54.3	Mixed mineral manure.
10 a, ...	14.2	11.9	7.3	33.4	31.1	93.1	400 lbs. ammonium salts.
7 a, ...	22.3	11.3	5.7	39.8	24.1	60.5	do. + mixed minerals.
11 a, ...	17.9	9.3	3.6	30.8	27.5	89.2	do. + super-phosphate.
8 a, ...	21.1	13.9	7.8	42.8	30.1	70.3	600 lbs. ammonium salts and mixed minerals.

From the above we note that the total nitric nitrogen in 27 inches of unmanured soil was 17.8 pounds per acre; while in the same soil, treated with mixed mineral fertilizers, the amount was 24.3 pounds per acre.

The percentage of nitric nitrogen which passed out in the drainage was also diminished as a result of the application of mineral fertilizers.

The effect of mixed minerals, when applied with ammonium salts in diminishing the loss of nitrates in the drainage, is well shown in the results from Plot 10a, 7a, and 8a, in the preceding table.

The Effect of Season of Year Upon Loss of Nitrates.

The preceding table shows that in unmanured land, and in land to which only mixed fertilizers, free from nitrogen, had been applied the percentage of nitric nitrogen removed by the drainage from September 1 to February 1, five months, was from 54 to 65 per cent. of the total quantity present in the first 27 inches of soil at the beginning of the experiment. In Table VIII similar results are observed.

On Plot 5, fertilized by non-nitrogenous manures, the average number of parts of nitrates per million parts of drainage for the whole year was 4.2 while the corresponding figures for the periods from wheat harvest to autumn sowing, and from autumn sowing to spring sowing, were respectively 4.8 and 5.5. The corresponding figures for the periods from spring sowing to the end of May, and from June to harvest, were 2.9 and 0.2.

The losses of nitrate in a wheat field, or on fallow ground are therefore greater during the fall and winter months; and least during the summer months.

The increased loss of nitrates in a wheat field during the fall and winter months is due to a combination of causes:

1. Diminished evaporation and increased drainage.

2. The accumulation of nitrates in the soil during the summer months beyond the needs of the plants, which are washed out of the same during the fall and winter, and

3. The inability of wheat at this season to utilize the soil water and prevent excessive percolation.

These considerations teach a most important principle, i. e., that ground should be kept in some crop as much of the time as possible especially during the fall and winter. The growth of wheat as one crop in a system of rotation is of course necessary, notwithstanding the inevitable losses of nitrates which follow its seeding.

There are, however, certain violations of the above rule which need correction.

Corn land should never be left fallow through the winter. The same is equally true of tomato and trucking land. Either these crops should be followed by wheat or some winter cover crop put in to conserve nitrates. In a loose sandy soil in which it is more difficult to accumulate available nitrogen it would be inadvisable to follow a cultivated crop like tomatoes, or potatoes by wheat, but rather to use crimson clover or rye to hold the nitrogen.

(*f*.) *Increasing the Supply of Available Nitrogen in the Soil.*

Soils may become too rich in humus and available nitrogen. The use of crimson clover has in some cases in Delaware been carried so far as to work actual injury to the land, especially if the latter has a tendency to become heavy and retentive of nitrates. The majority of farm lands, however, are not open to the charge of being too rich; on the contrary, the improvement of land and the growth of larger crops is the great desideratum.

I have already pointed out that most soils contain large supplies of organic nitrogen, which, by the aid of nitrification, can be made available to crops. The question of utilizing these stores of organic nitrogen already in the soil becomes mainly one of underdraining, deep plowing and more frequent cultivation.

Every cultivation of a corn or potato crop is equivalent to a dressing of nitrate of soda in its cheapest possible form. Hence if we could cultivate twice to each once by our present system we would

considerably increase our supplies of available nitrogen, and in turn reap the rewards of such an increase in larger crops.

Such a system of intensive cultivation carried on year after year would, however, result in the burning out of the land, and in greatly reducing the fertility. It is, therefore, necessary to make good these losses of organic nitrogen by the growth of such crops, or by the use of animal manures, as shall add to the stock of humus already in the soil. The effect of stable manure and clover in increasing the quantity of nitrates in the soil is brought out in the following table:[31]

Table X.

Nitrogen as Nitric Acid in Pounds per Acre in Soils of Geescroft and Hoosfield Experimental Plots, Rothamsted.

Depth—Inches.	I. Geescroft field, land in beans 30 years continuously, then 4-5 years fallow without manure.	II. Geescroft field as in I. Farmyard manure.	III. Hoosfield, wheat and fallow alternately for 35 years.	IV. Hoosfield, 17 years in clover, 12 years fallow and six crops grain in 35 years. No nitrogen manure.
1-9,	4.28	13.57	19.85	30.90
10-19,	5.52	8.76	8.05	27.73
19-27,	4.81	7.70	2.47	8.44
28-36,	2.69	8.51	2.70	7.64
37-45,	2.68	4.36	1.62	9.07
45-54,	1.90	1.85	3.57	8.77
55-63,	2.60	1.71	3.84	7.92
61-72,	3.47	—4.00	2.28	8.34
Total,	27.95	50.46	44.38	108.81

The results given in column I are from a field left for 30 years unmanured and exhausted by continuous cropping to beans, followed by fallowing. In column II it is seen how, even under condition of the most heavy drain upon a soil, the supply of available nitrogen can be maintained by the use of stable manure.

In columns I and II above, the comparatively large quantities of nitrates in the lower zones of the soil will be noted as indicative of the effect of excessive downward percolation during 4-5 years of fallowing; for this reason the soils of the Geescroft field are really poorer in available nitrogen, within that zone occupied by the bulk

of the roots, than the amount of total nitrogen to a depth of 72 inches would indicate.

In column III the effect of 35 years' continuous culture of wheat on the same land is shown; the result is a soil richer in available nitrogen than might be expected.

The comparative effect of 17 years in clover, as shown in the last column, is a marked increase of available nitrogen, and shows the good effect of such crops in increasing the store of this important element of plant food.

The effect of permanent grass in increasing the store of nitrogen in the soil is marked, and is well brought out in the following table by Sir. J. B. Lawes:[55]

Table XI.

Nitrogen in Surface Soil (dry), First 9 Inches, and Gains in Pounds Per Acre in Land in Permanent Grass.

Dates.	Number of years.	Nitrogen. Per acre—total lbs.	Gain. Per acre—total.	Gain. Per acre—per annum.
1856,	....	3,040	....	....
1866,	10	3,497	....	....
1879,	13	4,091	457	....
1888,	10	4,690	594	45.7
			599	59.9
Total,	33		1,650	50.0

It should be understood that the above field has been mowed for hay every year for 33 years, with average yield of 1.7 tons per acre per annum, and yet, notwithstanding this annual drain, there was an increase of nitrogen in the soil of 50 pounds per acre per annum.

Thus the state of knowledge is sufficient to indicate that all soils can be kept sufficiently rich in available nitrogen by the judicious use of leguminous crops in a proper system of rotation, or by the use of grass and clover as a part of the same system, and this with out the necessity of purchasing a single pound of nitrogen in a fertilizer.

6. Denitrification and Loss of Free Nitrogen.

Through the agency of bacteria present in all soils, nitrates under certain conditions may be converted into lower oxides of nitrogen, into ammonia or into free nitrogen.

Goppelsröder,[56] in 1862, made the observation that in soils rich in humus active denitrification took place.

In 1882, Gayon and Dupetit[57] found that in river water containing small quantities of nitrate of potash (0.02-0.2 grams per 1000) there was a reduction of the latter salt to ammonia.

The reduction of nitrates through the agency of bacteria was later (1883) observed by Dehérain and Maquenne,[58] and also by Springer,[59] which reduction they held to be due to the agency of anaerobic forms, similar to B. *butyricus*, which either reduced the nitrates to lower oxides of nitrogen or to free nitrogen.

Heraeus,[60] in 1886, isolated from water two bacilli which posessed to an eminent degree the power of reducing nitrates to nitrites. Blasi and Fravoli,[61] in 1888, found in Palermo soil 27 different species, which they have studied as to their chemical action in gelatin containing nitrates. They found that in 1-3 days the quantities of nitrates diminished with a simultaneous increase of nitrites. These latter reached their maximum in 6-8 days, and after 25-30 days entirely disappeared.

Frankland,[62] in 1888, isolated from water some 32 different species of bacteria, of which no less than 17 possessed the power more or less completely of reducing nitrates to nitrites. Of these the most strongly reducing were B. *ramosus* and B. *pestifer*.

Bréal,[63] in 1892, isolated from straw and other refuse a ferment which possessed strong reducing action. He found that if to straw fermenting in water, nitrates were added, the latter rapidly disappeared, while if sterilized straw were put into water and allowed to ferment, no such reduction took place, thus showing the presence upon the straw of some specific denitrifying organism. The nitrogen, according to the author, appeared partly in organic combination and partly as elementary nitrogen.

Gilthay and Aberson,[64] in 1892, isolated from both soil and atmosphere two organisms which possessed active powers in reducing nitrates, and which they named *Bacillus denitrificans* var. a. and b. Both of these liberated free nitrogen.

Egunow,[65] in 1893, isolated from the surface of seed a bacillus which possessed the power of reducing nitrates to nitrites, etc. Egunow found that in flasks with broad flat bottoms, with mineral media and nitrates, and with the fluid only a few millimetres thick, the nitrates were finally converted into ammonia. Where the thickness of the fluid was 10 mm., the nitrates were converted into am-

monia and free nitrogen. Where the thickness was 60-70 mm. no ammonia was formed, but only free nitrogen.

Burri, Herfeldt and Stutzer,[66] in 1895, isolated from horse manure and from straw two bacilli, respectively B. *nitrificans* I and II, which actively reduced nitrates.

Schirokikh,[67] in 1893, isolated from horse dung a bacillus which liquified gelatin, and actively reduced nitrates. In broth containing 2.5 grams of potassium nitrate to the litre, the latter was completely reduced in 5.8 days, at a temperature of 30-35 degrees C.

Again, Sewerin,[68] in 1897, isolated from horse manure 29 species of bacteria, of which 20 possessed greater or less power of reducing nitrates.

In 1896, Richards and Rolfs[69] conducted some experiments with 25 different solutions prepared to typify conditions of water polluted with decaying organic matter (sewage), and at the same time containing nitrates.

They note, (1) the rapid disappearance of nitrates, usually less than 10 per cent. of the original quantity remaining at the end of 3 days; (2) a corresponding increase of nitrites; (3) that when the solutions contained no organic matter other than that usually present in the water reduction took place very slowly and incompletely; (4) that the nitrogen which disappeared from the nitrates was finally given off in the free state; (5) that whenever nitrates were added to decomposing organic matter under such conditions that the growth of the bacteria required more oxygen than the solution afforded, the latter took it from the nitrates setting free nitrites, which in time were decomposed, setting free nitrogen.

From the aforegoing citations it is seen that denitrifying bacteria are abundantly distributed in nature, and that they are found in water, soil, manure, sewage and upon the surface of plants, particularly upon straw. It is only necessary to add a small portion of soil to media containing nitrates to obtain active denitrification thus showing the general presence of denitrifying bacteria in soils.

The majority of soil bacteria studied separately by the author possess this property to a greater or less degree.

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7. Conditions Affecting Denitrification.

(*a.*) *Presence or Absence of Air.*—It has commonly been supposed that the power of reducing nitrates belongs more exclusively to the anaerobic bacteria, or those which live without air. The question is an open one as to how far denitrification is the result of a deficient supply of atmospheric air. All of the species of soil bacteria so far

examined by the writer, with one exception, are aerobic, and yet they all actively reduce nitrates.

That active denitrification can take place in the presence of an abundant supply of atmospheric oxygen is shown by the following: A culture of B. *pulvinatus* was selected on account of its active denitrifying properties.

The bacillus was grown in a solution of Witte's peptone containing one gram of nitrate of soda to the litre.

Provisions were made for continually passing sterile air through the culture so as to provide an abundance of atmospheric oxygen. Simultaneously with the above, a culture was made in an ordinary flask, plugged with cotton wool, without aeration. At the end of 5 days 7.0 milligrams of nitrite of soda per 100 c. c. were found in the aerated culture and 30.0 milligrams in the non-aerated.

At the end of 10 days 20 milligrams of nitrite of soda were found in the aerated and 40 milligrams in the non-aerated culture.

In this case active denitrification took place even with abundant and continual aeration of the culture, although the presence of large quantities of atmospheric oxygen seemed to somewhat retard the process.

These results are in conformity with those of Stutzer and Maul.[70] B. *denitrificans* and B. *coli-communis* in a broth culture caused a vigorous reduction of nitrates to nitrites, and in four days the nitrites had entirely disappeared, when, however, a constant stream of air was passed through the culture, growth took place as before but the nitrates had not entirely disappeared until after the tenth day.

It would, therefore, appear that denitrification can take place actively even in the presence of an abundant supply of atmospheric oxygen, certain bacteria at least being capable of utilizing combined oxygen equally with that supplied in the free state.

Contrary results were obtained by Pfeiffer, Franke, Götze and Thurmann[71] in their study of the loss of nitrogen in manures. They found that denitrification was more active when air was drawn through and over the manure than when air was excluded, the presence of atmospheric air apparently favoring the process, and it has become a recognized principle that manures lose nitrogen less readily when kept closely compacted than when loose.

(*b*.) The Presence of Organic Matter.

The effect of organic matter upon the development of the denitrifying organism was shown by Stutzer and Jensen in 1897.[72] The experiments of the latter indicate that denitrification can take place only in the presence of a sufficient supply of assimilable carbon,

otherwise the nitrates remain unaltered although the denitrifying organism may be present in abundance. Apropos to this principle the authors hold with Maercker that horse manure is more active in causing denitrification than sheep or cow manure since the former is much richer in assimilable carbon than the latter.

It is a well known fact that denitrification is particularly active in stable manure, and denitrifying bacteria are especially abundant therein. The admixture of straw also favors the denitrification process in manure was accelerated by the addition thereto of a straw contains an easily assimilable carbon in the form of pentosans. The pentosans which are abundant in coarse manure and straw, furnish a much more readily available food to denitrifying organisms than cellulose or fibre. Still more readily assimilable forms of carbon are found in such compounds as glycerin, citric acid, lactic acid, etc., and Pfeiffer and Lemmermann found that the denitrification process, and an explanation of this has been found in the fact that soluble calcium citrate.

The loss of nitrogen in the free state in organic infusions seems to be associated with the presence of readily decomposable nitrogenous bodies, such as the *amides.* Thus Grimbert [72.5] found that the colon bacillus, when grown in a solution containing peptones and nitrates, yielded no free nitrogen, but when grown with nitrates in a solution made from beef extract and containing amides there was a considerable loss of nitrogen in the free state.

The author, therefore, concludes[1] that the nitrogen does not come exclusively from the nitrates, but also results from the denitrifying action of the bacillus upon amido principles in the culture medium.

2. That the evolution of free nitrogen seems to result from the secondary reaction which nitrous acid, formed by the bacteria, exerts on these amido substances.

It has been seen that one step in putrefaction and ammonification is the production of amido acids and basic amines, and this explains perhaps the rapidity of the denitrifying process in infusions rich in nitrogenous organic matter which are undergoing putrefaction.

Kinger[73] showed that when nitrate of soda was mixed with liquid manure (urine) there was a decided decomposition of nitrogenous compounds and loss of nitrogen. And in the same connection, T. B. Wood[74] found that nitrate of soda when used alone as a fertilizer for oats gave much better results than when used with manure.

This simply reiterates the former principle that nitrates readily decompose in the presence of an excess of readily assimilable organic matter.

(*c*.) The Relation of Denitrification to Cultivation.

It has been stated that denitrification may take place either in the presence or absence of atmospheric air.

With the presence of some form of easily assimiliable organic matter, it may take place under any condition of aeration.

Nitrification is the opposite and antagonistic process to denitrification. Furthermore, the conditions which are favorable to the former are inimicable to the latter.

The question of denitrification and loss of nitrogen in soils is one about which much has yet to be learned, but it is generally believed that under ordinary conditions it is of no particular importance. At least this much may be said, that if the agriculturist will maintain those conditions which are favorable to nitrification, any possible loss of nitrogen by the opposite process can be disregarded.

Hence cultivation, which effects the rapid destruction of easily assimiliable organic compounds, leaves little opportunity for the denitrifying bacteria to carry on their destructive work.

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8. The Loss of Nitrogen From Stable Manures and its Conservation.

It has been stated that denitrification and loss of nitrogen is comparatively rapid in stable manures, because of the abundant presence of denitrifying bacteria and of easily assimiliable organic compounds which furnish food to the latter. It has also been noted that straw mixed with urine and excrement also assists the process by furnishing an easily assimiliable carbon compound in the form of pentosans.

So deleterious is the action of straw that it has been suggested, as a feature of good farm practice, to keep the manure and litter separate, or to see to it that as little straw as possible becomes mixed with the urine and faeces.

To what extent this is practicable must be left to the practical agriculturist to determine. But taking conditions as they ordinarily exist, i. e., with straw forming a considerable proportion of the manure proper, and with the natural losses of nitrogen which must take place to confront us, how can these be reduced to the minimum.

There are two methods for conserving the nitrogen content of stable manure, first, by the exclusion of air and second, by the use of preservatives.

Regarding the first method it has been shown that denitrification is more active when air was drawn through and over the manure than when it was excluded.

Under the former condition of free access of air Franke, Götze and Thurmann showed a loss of nitrogen amounting to from 27.6 to 42.6 per cent. of that originally present.

Hence to prevent loss of nitrogen the manure should be kept well compacted; its storage in sheds, or even in closed receptacles, whereby it is protected from strong currents of air, is also advisable.

The preceding authors have also made valuable experiments on the use of preservatives. Of these, the use of super-phosphate is especially recommended.

In this case the transformation of the nitrogen in the form of free ammonia into free nitrogen was prevented by the use of a sufficient amount of the super-phosphate to combine with all the ammonia formed, thus fixing it and preventing its loss. Plaster or sulphate of lime acts in the same way but less energetically.

The addition of 2-3 per cent. of caustic lime, or 5 per cent. of marl, decidedly reduced the denitrifying power of fresh manure.

The use of caustic lime, however, is not to be advised as it was found to promote ammoniacal fermentation, and the loss of ammonia.

According to the authors, the mechanical condition of the manure exerted a more marked effect upon its preservation than chemical preservation. Hence the keeping of the manure in a well compacted condition and free from strong currents of air is of primary consequence.

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9. The Disintegration and Dissolution of Mineral Matter.

This subject has, in a measure, been discussed in previous pages, but a few additional statements, in this connection, might be made.

The mineral elements of plant food are absorbed in the form of salts. These salts are compounds of acids and bases, as shown in the following list:

Plants Absorb.

Acids.	Bases.	As Salts—i. e.		
Nitric,	Ammonia,	Nitrates,	of	Ammonia.
Sulphuric,	Potash,	Sulphates,		Potash.
Carbonic,	Lime,	Carbonates,		Lime.
Phosphoric,	Iron,	Phosphates,		Iron.
Silicic,	Soda,	Silicates or		Soda or
Hydrochloric,	Magnesia,	Chlorides,		Magnesia.

Of these acids, certain of them have existed in the rocky crust of the earth, from which soils have originated, before the advent of life, and hence are not of bacterial origin. These are sulphuric, phosphoric, silicic and hydrochloric acids. Others of them are products of bacterial life such as carbonic and nitric acids.

Of the bases, all except ammonia are of primordial or earth crust origin.

Of the salts, the sulphates, silicates, carbonates and chlorides, which are largely present in rocks, are not absorbed except in minute quantities, the greater part of the bases being taken up as nitrates and phosphates, and also as salts of the organic acids.

In the process of nitrification the nitric acid combines with the various bases present in the soil, and nitrates are produced.

Phosphoric acid exists in the soil in the form of insoluble basic phosphates, which, under the action of organic acids, are converted into neutral or acid salts which are soluble. Hence the production of organic acids by bacterial fermentation renders phosphoric acid available to plant roots.

We have already spoken of the action of carbonic acid, in disintegrating, and setting free as carbonates, the various bases locked up as mineral silicates. These carbonates unite with silica to form zeolites and these in turn are slowly decomposed by organic acids, and their contained bases again liberated as organic salts.

H. Carrington Bolton has shown that many minerals are slowly decomposed by the action of cold citric acid, the zeolites and other hydrous silicates being especially susceptible.

Thus by the combined production of carbonic, nitric and the various organic acids, through the action of bacterial life, we have all the necessary agencies at hand for the dissolution of the mineral elements of plant growth.

VIII. THE ASSIMILATION OF ATMOSPHERIC NITROGEN.

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1. Historical Summary.

The Biology of Root Tubercles.—It is a fact familiar to all that the roots of leguminous plants contain nodular swellings or excrescences known as "root tubercles."

These have been recognized from the earlier days of botanical inquiry, and as far back as 1615, DeLéchamp used the characters of the root tubercles as a basis of classification, and the same use was made of them by DeCandole[75] in his System of Vegetation.

At different periods during the earlier part of the nineteenth cen-

tury various opinions were held by different authors regarding these bodies. The more general view was that they were of the nature of fungus growths, or otherwise diseased conditions of the roots; a few held them to be the result of animal parasitism, and due either to insects or worms; while others considered them to be normal organs, regarding whose function there was difference of opinion.

All of these latter views were, however, purely speculative, rather than based upon any serious study; and it was not until 1866 that any attempt was made to study them closely; when Woronin[15] described their microscopic structure.

He found them to be composed of a central portion of thin walled cells, of an outer rind, and of an intermediate layer or vascular ring. In the central portion the contents were cloudy, and closer examination showed the cells in this portion to be filled with peculiarly shaped bodies, which were sometimes rod-like, at others forked, and presenting a variety of forms simulating the letters T and Y. Woronin regarded these bodies as living organisms, but since they differed from other bacteria or *Vibros* in form, he termed them *Bacteroids*. He regarded them as the causative agents in the formation of the tubercles, although he offered no proof of this assumption.

In 1874, Erickson[17] found in the newly developing tubercles long branching filaments resembling the mycelium of a fungus.These threads he considered to be the infecting agents. Later on in the development of the tubercles he observed the presence of the bacteroids, noted by Woronin, but failed to connect the two as corelated structures.

In the early observations of Woronin and Erickson we have the germ and substance of all that has since been discovered regarding root tubercles. Both recognized, as is held to-day, the two classes of bodies the filamentous and the bacteroid. Both were right in assuming that the organisms as seen within the tubercles were the agents in their production, although Erickson was more nearly right in assuming that the filaments were the real infecting agents.

But it was left to others to show the relation of the filaments to the bacteroid bodies, and this question became the subject of much controversy and difference of opinion extending over many years. In the controversy which followed, covering the latter 25 years of the nineteenth century, the most eminent botanists were engaged.

On certain points they agreed, on others they differed, but since the points on which they differed determined the position which these forms should occupy in a system of classification, the subject became of especial interest.

All agreed to the presence of the filaments within the tubercles in the early stage of their development. These filaments were fur-

thermore regarded as the infecting parts, which forced their way into the younger roots and, by their iritating presence, set up a multiplication or proliferation of cells which resulted in the building up of an excrescence or tubercle.

It was upon the structure of the filaments, and upon how the bacteroid bodies originated from them, that they differed, and upon this point it is surprising that there should havebeen such a wide diversity of view. These two views class themselves under two heads, which, for the sake of convenience, we shall term the endogenous and the exogenous theories. The former was held by Prazmowski, Frank and Maria Dawson, and the latter by Laurent, Ward and Atkinson.

According to Prazmowski,[78] the leader of the endogenous theory, the infecting agent in the production of the root tubercles is present in the soil as a definite bacterium, which, after Beyerinck, he calls *Bacterium radicola*.

Certain of these force their way into the smaller roots and for a time multiply therein; but soon the juices of the plant exert an unfavorable influence upon them, and to protect themselves against its injurious action they excrete a gelatinous substance in which they remain embedded, and in which they continue to multiply. With this multiplication the gelatinous envelope is drawn out into long strands or filaments, containing the rod-shaped bodies or bacteria. As long as these remain protected by their gelatinous envelope they continue to multiply and retain the rod-shaped form.

As the filaments approach the central portion of the tubercle they swell out into rounded vessicles. Later on by the enlargement of these latter the enveloping membrane becomes so thin that it bursts and the enclosed bacteria are set free. From this time they cease to multiply, and by degeneration assume a variety of irregular branched forms, first observed by Woronin, and called by him bacteroids. Prazmowski, therefore, recognized (1) that the filaments were elongated pouches of gelatinous matter, the secretion of the bacteria, and in which the infecting bacteria were embedded; (2) that these bacteria multiplied as straight rods within the filaments, or endogenously; (3) that by the escape of the bacteria they underwent various degenerations by which they assumed the irregular forms of bacteroids.

One essential point in Prazmowski's position was that the bacteroids were degenerated forms.

Frank[79] in his later observation, held to the position of Prazmowski, but differed in regarding the gelatinous envelopes as a product of the cell rather than of the bacteria.

Maria Dawson[80] in 1899, also held to the view of Prazmowski. By proper staining she found the filaments to consist of strands of

straight rodlets lying parallel to the longer axis of the filaments and embedded in a colorless matrix. This matrix did not consist of cellulose, chitin, or any form of slime. The swellings, or vessicles of Prazmowski, occurred at places where the rodlets had become heaped up and eventually had burst liberating the rodlets. After liberation from the filaments they became transformed into X, V and Y shaped bacteroids.

The exogenous theory is best represented by the researches of Laurent in 1891,[81] and later by those of Atkinson in 1893.[82]

Both hold that the filaments are not pouches containing bacteria, but true homogenous filaments, which, as they enter the cells of the central portion of the tubercle, show enlargements which afterwards, by a process of budding, give rise to the branched bacteroid bodies.

This view was also held by Ward[83] somewhat earlier, and all agree in regarding the organism as a lowly organized fungus instead of a bacterium whose filamentous portion corresponds to the mycelium, and whose bacteroids are buds or gonidia thrown off from the latter. For this fungus, Laurent adopts the name *Rhizobium leguminosarum* originally proposed by Frank.

Regarding these two views the bulk of evidence inclines to the exogenous theory, although there is opportunity for further study before the matter is finally settled.

In what has been already said it was assumed that the root tubercles of leguminous plants are caused by an organism, commonly present in the soil, which infects the younger roots and results in the formation of excrescenses or tubercles.

In the earlier researches on the structure of the tubercle and their contained organism it was assumed that the associated fungus was the cause of the tubercle. But the first demonstrable proof of the relation of soil organisms to the development of tubercles was due almost simultaneously to Hellriegel[84] and to Ward,[85] in 1886.

Hellriegel grew peas in sterilized sand free from nitrogen, but to which the other mineral fertilizers had been added. The plants grew until the stock of nitrogen in the seed was exhausted, when they showed signs of starvation. To these starving plants were added infusions of soil in which peas had previously been grown; in one case this infusion was sterilized, and in the other not. When unsterilized soil infusion was used, the plants began to revive their vigor, and continued to grow to maturity. On their roots numerous tubercles developed.

In the case of the plants watered with sterilized soil infusion, the plants did not revive, and no tubercles formed.

From this experiment and others of like character it was shown that something, probably a living organism, existed in the soil in-

fusion, which was capable of infecting the roots and causing the formation of tubercles; and that by heat this organism could be destroyed.

The experiment also showed that the renewal of vigor of the plant in a nitrogen free soil was corelated with the infection of the roots and the formation of tubercles; in other words, tubercle formation and nitrogen assimilation by the plant were interdependent.

From this point the question of tubercle formation passed from one of mere botanical interest to one of great agricultural importance.

Ward[85] went even further, and besides showing that tubercles could be produced at will by the inoculation of roots with soil infusions, succeeded in tracing the development of the fungus filaments into the root hairs, and thence into the cortex of the root, where he noted the development of the tubercles at these points of infection.

In 1888,[86] Beyerinck, succeeded in cultivating the root tubercle organism on artificial media, and described a number of races from different plants, which he considers varieties of one species of bacteria and which he names *Bacillus radicicola.*

In 1890, Prazmowski,[78] by cultivating the organism of the root tubercles of beans ,succeeded in inoculating their roots with pure cultures of the latter by watering sterilized soils in which the plants were grown, with liquid cultures of the organism.

In 1891, Laurent,[81] by growing legumens in water culture, succeeded in inoculating their roots and producing tubercles at the points of inoculation by puncturing them with a needle whose point was contaminated with root tubercle germs. And a little later, Atkinson[82] succeeded, by growing vetch in water culture, in inoculating their roots and producing tubercles from pure cultures of the organism.

There is thus no doubt but that tubercles on the roots of leguminous plants are produced by infection from without, and by an organism entering the root from the soil.

The organism as it exists in the soil is probably in the form of bacteria-like bodies, and most soils contain them in greater or less abundance. Their method of infecting the root is best described and figured by Atkinson.[82]

The bacterial body has the power to penetrate a root hair and is first seen therein as a filament, extending its entire length, as shown in Fig. 7 B-C, and thence entering the cells of the cortex of the root, causes their proliferation and the production of a swelling upon the side of the root, Fig. 7 A, which by further growth becomes a tubercle. Within the central cells of this tubercle the filaments can be seen branching in all directions as seen in Fig. 8 A.

At numerous points are seen irregular swellings, Fig. 8 A-B,

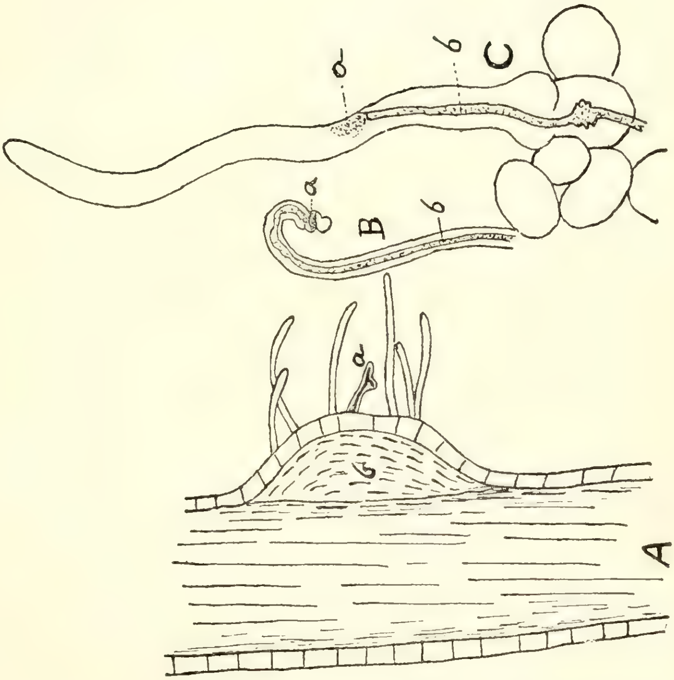

FIG 7.—Root tubercle formation. Infection of root through root hairs. A, a, infected root hair; b, beginning of a tubercle; B, a, point of entrance of infecting filament into root hair; b, infecting filament; Ca-Cb, as before. (After Atkinson.)

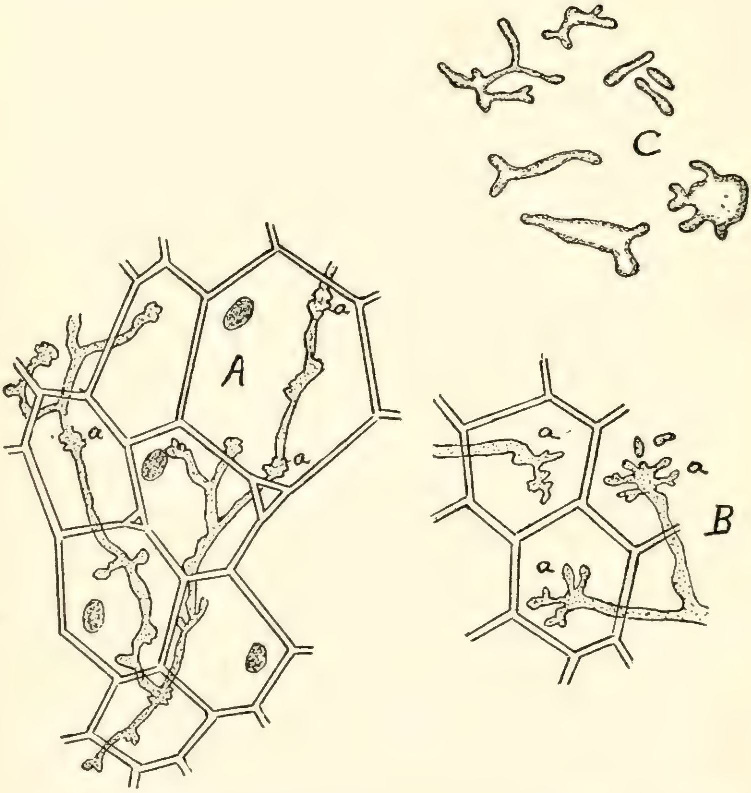

FIG. 8.—Root tubercle formation. A, ramification of filaments within central cells of tubercle; a a, enlargements of the latter from which buds originate. B—aa, showing budding of filaments and production of bacteroids. C, bacilliary and bacteroid bodies. (After Laurent.)

which later on produce buds which become bacterial and bacillary bodies, and which eventually fill the cells of the central portion of the tubercle.

Such in brief is an outline of the biology of the root tubercle organism. For a further exposition of the subject the reader should consult the excellent paper of Atkinson.

2. The Relation of Root Tubercles to Nitrogen Assimilation.

It has long been known that clovers enrich land, but the full philosophy of the matter has not been fully understood until comparatively recent date.

Lachmann,[35] in 1858, was probably the first to suspect that certain nodular bodies seen upon the roots of legumes were in some way connected with the absorption of nitrogen by the plant, but no experimental proof of this assumption was given.

In 1864, Rautenberg and Kuehn[37] gave the first inkling of this in their work on water cultures. They noticed that with certain legumens grown in water, nodules formed on the roots of only those plants which were growing in a solution free from some compound of nitrogen. The presence of nodules, therefore, seemed to be associated with an effort on the part of the plant to obtain nitrogenous food.

DeVries,[38] a little earlier, observed that comparatively few nodules developed on plants to which an abundance of nitric nitrogen was supplied. Root tubercle development, therefore, seemed to be associated with nitrogen hunger. But an exact demonstration of the relation of root tubercles to nitrogen assimilation by the plant was not made until 1886, when Hellriegel announced his important series of researches.

Hellriegel[24] was able to grow peas and other legumens in pure sand absolutely devoid of nitrogen, but supplied with other plant food. The sand was sterilized so as to destroy all germ life therein. Peas etc., grew in such a soil only under certain conditions, i. e., when the soil was infected with an infusion containing the living germs of root tubercles. Soils inoculated with sterilized infusions, or soils not inoculated and previously sterile, failed to grow peas.

In the infected soils the peas developed tubercles, and with their development the plants thrived and attained their full maturity. Since the soil was devoid of nitrogen, the plants could have gained the nitrogen for their fruition from but one source, and that was the atmosphere.

Hellriegel thus, as a result of an elaborate series of experiments, was able to announce positively that leguminous plants were able to utilize the free nitrogen of the air.

But an announcement so radical and startling as this could not rest on the authority of one man alone, and accordingly, Hellriegel's experiments, with modifications, were repeated by numerous investigators, notably, Nobbe, Hiltner and Schmid,[89] with the same results.

In Hellriegel's experiments his plants were grown in the open air, and since atmospheric air contains combined nitrogen in the form of ammonia and nitrous acid, it was a question, though the soil might be free from nitrogen, whether the nitrogen compounds present in the air might not be the source of nitrogen to the plant instead of free nitrogen.

Accordingly, in 1892, Atwater and Woods,[90] in this country, grew peas in glass cases the air of which was free from every trace of combined nitrogen. The soil and nutrient solution used to water and fertilize the plants were also nitrogen free. At the end of the experiment, covering 85 days, 27 plants had made an average growth of 29 inches, with a total gain of 242 mg. of nitrogen. It was furthermore noted, that as a rule the largest gains were in those plants which showed the largest tubercle development. Thus, the authors conclude, "The free nitrogen of the air was alone available to the plants, and the gain must have been by the acquisition of free nitrogen."

There is, therefore, no longer any doubt remaining in the minds of scientists that leguminous plants possess the power of utilizing the free nitrogen of the atmosphere.

It has also been shown that they do this in proportion to the poverty of the soil in available nitrogen. In other words, the plant does not utilize the function of appropriating free nitrogen unless forced to do so.

A legume will thrive in the presence of an abundance of available nitrogen in the soil, or will respond to a liberal application of nitrate of soda. And it does so because it is easier for it to utilize a form of nitrogenous plant food already prepared for it than to go through the more elaborate process of appropriating the free nitrogen of the air.

But if the soil be deficient in nitrogenous food the legumes will extend their appropriating energies along these new lines, eventually overcome their soil environment and come off the victor.

On this principle is based the value of leguminous plants as soil enrichers.

It has been stated, and has perhaps been fairly well established, that the increase in nitrogen in legumes is proportionate to the development of tubercles.

In his experiment with beans, Halsted[91] found that in every case there was a decided increase in yield of beans on soils where several successive crops of beans had been grown, over the yield where

grown on a soil for the first time. The roots of the plants growing upon old ground were well supplied with tubercles, while in the new soil they were usually almost entirely absent.

Lane,[92] in New Jersey, obtained similar results with the cowpea, when grown for three successive crops on the same land. The first season but few tubercles were noted, and the yield was 6.56 tons per acre. The second year the tubercles were more abundant and the yield was 7.19 tons per acre. The third season the tubercles grew abundantly and the yield per acre was 10.02 tons.

The fertilizer applied the third season was less than one-half that applied the second and it is believed that the increase was due in a large measure to a greater abundance of tubercles.

It is a general observation that both annual and perennial legumes grow better a second season than they do the first, and this is probably due to a larger seeding of the soil with the organisms necessary to the production of tubercles on the roots.

It is claimed by Nobbe and others that root tubercles exert no influence in nitrogen assimilation when there is an abundance of available nitrogen in the soil. The tubercles being held to be the organs for such assimilation, this amounts only to saying that these organs will not perform this function unless called upon to do so, but let this necessity be forced upon the plant, the function of the tubercles is exercised, and the greater their number the greater will be the gain of the plant in nitrogen.

Furthermore, the poorer the soil in available nitrogen, as shown by Hiltner[93] in the case of *Alnus glutinosa*, the greater is the number of root tubercles which will develop, provided the necessary organisms are present in the soil. Hence under conditions of nitrogen starvation or deficiency the number of tubercles on the roots becomes a measure of the nitrogen assimilating activities of the plant.

3. Do Other Plants Than Legumes Assimilate Free Nitrogen?

The power of legumes to assimilate free nitrogen does not rest on the fact that they belong to a certain family of plants, the Leguminosae, but rather to the fact that their roots contain tubercles. This is instanced by the common alder whose roots bear tubercles. Hiltner has shown that young alders without root tubercles, and deprived of combined nitrogen, are unable to assimilate atmospheric nitrogen, and that the plants are poorly developed. But when by inoculation, tubercles are produced, the plant can utilize free nitrogen as in the case of legumes. This is well illustrated in Fig. 9.

The alder is therefore the one non-leguminous plant which is able to assimilate atmospheric nitrogen.

Regarding other non-leguminous plants, the question of nitrogen assimilation has been raised, but the answer has, on the best authority, been in the negative. Thus Lotsy[94] showed the inability of white mustard to utilize free nitrogen and the same was shown by Nobbe and Hiltner[95] regarding mustard and buckwheat.

So far as present knowledge goes we may, therefore, assume that plants without tubercles are unable to utilize free atmospheric nitrogen.

4. Are There Different Species of Root Tubercle Organisms.

This is a question which has frequently been raised, but which as yet cannot be positively answered.

Nobbe held that there is a separate race of bacteria for each species or group of nearly allied species of plants. On the other hand Mazé, an equally good authority, claims that there are certain physiological forms of bacteria determined by the nature of the media in which they are developed. These are able to inoculate the roots of plants growing in soils offering the proper conditions for their development.

Beyerinck[96] has made a careful study of the different forms of bacteroids found in different species of legumes, and records differences among them. Voelcker[97] illustrates 16 different forms of bacteroids from different species of legumes, but states that no cultivating these organisms on nutrient media their differences disappear and that they can no longer be distinguished the one from the other.

This would indicate that differences in the form of the organism, as seen within the plant, has little significance, and is controlled perhaps entirely by the differences in the host. For it is a well known fact that one and the same bacterial organism will often present variations in form when grown in media of different character.

It is thus evident that the question of differences of species cannot be settled from the standpoint of differences of form, but must be determined from the physiological side.

Nobbe, Hiltner and Schmid[98] have thrown important light on the question in their inoculations of different legumes with pure cultures.

Their experiments show that the organism from a single species of legumes is capable to a greater or less degree of infecting and of producing tubercles on the roots of a number of distinct species. Thus the vetch can be infected by means of culture from Robinia (locust) Acacia, Vicia (vetch), and Pisum (pea); but the greatest de-

FIG. 9.—Alnus in sterilized soils. Pot 1, inoculated with bacteria from Alnus tubercles. Pot 2, soil not inoculated. (After Hiltner.)

FIG 10.—Robinia pseudacacia in nitrogen free soils. Pot 1, inoculated with bacteria from pea tubercles. Pot 2, inoculated with bacteria from Robinia tubercles. (After Nobbe, Hiltner and Schmid.)

velopment of the vetch took place when its roots were inoculated with vetch organisms. In other words, a given legumen is most susceptible to organisms of its own kind, and but feebly so to those of another species. (See Fig. 10.)

In the following table are given the results of these inoculations by the above authors:

Chemical Analysis of Plants.

	Inoculated With Pure Cultures From			
	Robinia.	Acacia.	Vicia.	Pisum.
Robinia dry substance—grams,	7.402	1.158	0.858	1.479
Robinia nitrogen—milligrams,	232.100	16.600	13.500	21.100
Acacia dry substance—grams,	1.953	6.943	1.248	1.817
Acacia nitrogen—milligrams,	17.000	109.800	16.200	19.700
Vicia dry substance—grams,	0.783	0.866	9.133	1.033
Vicia nitrogen—milligrams,	12.900	14.700	264.000	22.600

The differences here noted can only be explained by a consideration of the question of virulence of the organism, and of specific adaptation.

The pea tubercle organism by its growth in the pea root becomes especially adapted to that host, and losses its adaptability to another host. This, however, is a property more or less elastic, and subject to artificial modification.

Thus Nobbe and Hiltner [99] have shown that when peas were inoculated with cultures from bean tubercles, some tubercles would be formed but the organism seemed to be without the power of assimilating nitrogen; but if the same inoculation was continued upon a second generation of plants, the bacteria became nearly as efficient as those from the roots of the same genus. In other words, by passing pea tubercle bacteria successively through beans, the virulence at first feeble was decidedly increased.

The same authors have also shown that different cultures possess different powers in producing tubercles. Thus if a plant already possessing tubercles is inoculated with a culture of the same virulence there is no increase in the number of tubercles, but when inoculated with a culture of a higher virulence there is an increase in the number and size. The authors, therefore, hold that a plant may

acquire a certain immunity against infection by bacteria of a certain degree of virulence.

This may account for the failure of land in many instances to grow clover, so called "Clover sickness," when there is reason to believe that the soil is well supplied with the specific organisms.

To return to the question of species among different root tubercle organisms, it may be concluded that distinct species do not exist, and that there is but one species of variable virulence, capable of infecting the roots of any of the legumes either feebly or readily. That this species, which may at first attack a given host but feebly, has its virulence so increased by repeated growth in that host that it eventually is able to produce ready infection.

5. Relation of the Soil to Tubercle Production.

It has been stated that legumes will grow readily in soils where there is an abundance of available nitrogenous food independent of their power to assimilate atmospheric nitrogen. The legumes, however, are so rich in nitrogen, and such vigorous growers as a rule, that their demands for nitrogen are greater than those of any other class of agricultural plants. Hence, in ordinary soils, legumes must utilize their nitrogen assimilating function to a greater or less degree.

In poor soils, and these are the ones in which we desire to grow legumes as soil enrichers, there is often at first a struggle on the part of the legumes for existence, particularly is this true when a new legume is introduced.

It is assumed that in most soils root tubercle organisms of one variety or another exist, but often in such few numbers or in such an attenuated form as to feebly affect the plant. In this event an introductory crop of that legume, however small, may be necessary for the purpose of stocking the soil not only with the necessary number of organisms but with those of the proper degree of virulence. Soils, therefore, become adapted to the growth of any legume and this adaptation consists in an abundant supply of organisms of the proper virulence to infect the roots.

Nothing directly is known regarding the relation of soil acidity to the life of root tubercle bacteria therein, but Salfeld found that the addition of lime to land was beneficial to the development of root tubercles on field peas, lentils and garden peas.

6. Inoculations of Soils.

As soon as it was shown that root tubercle development was dependent upon the presence in the soil of specific organisms, the question of seeding the soil with such organisms was raised. The experiments which have been conducted on seeding land with soil in which the specific organisms of any leguminous tubercles are known to exist, have sometimes given positive and at others only indifferent results.

The positive results have usually come from the inoculation of virgin soils, moorlands or barren soils that have not previously born leguminous crops.

Salfeld,[100] in North Germany, obtained excellent results on the large scale on recently reclaimed moorlands sown to peas and beans which had received applications of lime, phosphatic slag, kainit and nitrate of soda, together with small quantities of fertile loam from fields that had previously born good crops of these plants.

In this case it was probable that the soil was deficient in nodule producing bacteria. Freewith[101] found that in plots containing lupines, and inoculated with lupine soil at a rate of 1,600 to 3,200 pounds of earth per acre, there was an increase in yield of stems, leaves and hulls of from 67 to 72 per cent. In plots containing serradella, and inoculated with serradella soil, at the rate of 80 pounds to the acre, there was an increase of yield of fodder of from 41 to 282 per cent.

In the latter case tubercles were found on the roots of the plants grown in inoculated soil, while they were absent in those grown on uninoculated land. In this case there must have been an absence or deficiency of the proper organisms present, which were supplied by the soil inoculations.

Soils which have been previously uncultivated are more likely to respond to soil inoculation than those which have been under tillage. Thus Schniftes[102] found that when cultivated clay soil was inoculated with earth containing bacteria from the root tubercles of lupines no favorable results were obtained. But when soil previously uncultivated was inoculated in the same way the increase of yield was from 11 to 32 per cent.

Otis,[103] of Kansas states that soy beans have been grown for eight years at the Kansas Station, but during that time tubercles were not found on their roots. Accordingly he secured soil from Massachusetts in which tubercle bearing soy beans had been grown. This soil was used to inoculate the Kansas soy beans. All the inoculated plants showed tubercles; there was also, as compared with uninoculated plants, a greater diameter of the lower part of the stem. Analyses of the crop showed also a slight increase in nitrogen, protein and water content.

Instead of soils, use has recently been made of cultures of the bacteria found in the root tubercles. Such cultures have already become a commercial product under the name of *Nitragin.*

The organisms are grown upon a specially prepared gelatin medium. Cultures from different legumes are made and sold, so that the proper organisms can be supplied for any given leguminous plant.

In using the cultures, the tubes containing them are placed in luke-warm water having a temperature of about 90 degrees F., to melt the gelatin and disseminate the germs throughout the medium. This is then mixed with a small quantity of water, and in this the seed is immersed previous to sowing, or the diluted cultures can be mixed thoroughly with earth and the latter sown broadcast over the land, immediately after the seed is sown. In immersing the seed in the solution the germs are brought into immediate contact with the developing plant, when root infection is more apt to follow.

The experiments on the use of nitragin have been so extensive and varied that it will be unprofitable to detail them here. Furthermore, the results have been so contradictory that confusion is likely to overwhelm the reader were we to review them.

In many cases increased yields have followed the use of nitragin, in others no benefit has resulted. Perhaps the failure in many cases has been due to the use of inactive nitragin, but, in most instances, it was likely owing to the fact that the necessary organisms were already abundantly present in the soil.

The question of the inoculation of soils, either with soils or with nitragin, therefore, resolves itself into one of whether the necessary organisms are already present.

In the cases where beneficial results have been attained, the soils on which it was used was either barren or otherwise below the standard of what might be classed as fertile soils. In the case of poor, sandy or worn-out lands, nitragin will doubtless be useful in initiating a good growth of any particular legume, until by a first crop the soil shall become well supplied with the necessary bacteria; after that there would be no advantage in its further use. In ordinary arable land some form of the tubercle organism is probably present in proper numbers to infect the roots to a degree sufficient at least to stock the soil with organisms of the proper virulence for another season.

Cases where nitragin is advisable are, therefore, the exceptions rather than the rule, and on this point no hard and fast lines can be drawn. The indiscriminate use of nitragin has led to many failures and disappointments. Like all good things when wisely used it is useful, but when used without judgment it is liable to meet with unjust condemnation.

7. Increase of the Nitrogen Content of Soils.

It is a familiar fact that land left to itself in an undisturbed condition increases in fertility from year to year. In the forests and prairies of our own country we have profited by the accumulated fertility of centuries, and much of our present National wealth we owe to those biological processes of the soil we are about to enumerate.

By these we mean the ability of the soil to accumulate nitrogen through the agency of microscopic organisms, and the lower classes of plants. Every observer is familiar with the growth of lichens on bare rocks on which no organic food, much less nitrogen in any appreciable quantity, is present; and yet such plants contain nitrogen and contribute it to the thin mantle of soil which slowly accumulates over rocky surfaces.

Fungi are frequently found on sterile sand in which only an inappreciable quantity of nitrogen is present, and yet they may store up in their tissues quantities of nitrogen greatly in excess of what the soil is able to furnish.

Mulder showed that moulds grown upon non-nitrogenous substances always contain protein, and his experiments are quoted by Storer.

In aqueous solutions of sugar left "for three months in stoppered bottles, with a seven fold volume of air, an abundance of mould grew, which, on being collected and subjected to dry distillation gave off large quantities of ammonia. So, too, starch kept under water in a bottle that contained air soon fermented, and the fungus which it had nourished gave off ammonia on being distilled."

It is now generally recognized that fungi, microscopic algae, and perhaps other of the lower cryptogams, possess greater or less power of fixing atmospheric nitrogen.

Bertholet[104] held, and, in fact demonstrated, that certain microscopic organisms of the soil do appropriate the free nitrogen of the air. During the growing season, in clayey and sandy soils, he observed a slow but continual fixation of nitrogen from the air. This increase, furthermore, failed to take place when the soils were sterilized by heating them to 230 degrees F. From this it was concluded that the fixation of nitrogen was due to certain micro-organisms which were destroyed by the heat. Bertholet, from his laboratory experiments, calculated that as much as 75 to 100 pounds of nitrogen per acre could be fixed in this way, and in two exceptional cases as high as 525 and 980 pounds to the acre.

A number of chemists, notably, Koenig, Kiesow, Armsby, Birner, Kellner, Dehérain and Avery[104] found that when organic matter in one form or another undergoes fermentative changes of a putrefactive character, there was frequently an increase of nitrogen in the

fermenting substance. This was particularly marked when the materials were kept alkaline with carbonate of soda or lime.

The explanation given for this increase was that a combination of nascent hydrogen evolved during the fermentation took place with the free nitrogen of the air by which ammonia (NH_3) was produced.

It is known that hydrogen is a common product of putrefactive fermentation, and it is highly probable that when such putrefactive changes take place in the soil there is a certain fixation of atmospheric nitrogen.

The claim of Bertholet that micro-organisms of the soil possess the power of utilizing free nitrogen led Winogradsky[105] to test the validity of this assertion. Of 15 separate species of soil bacteria isolated by him only one of them was able to assimilate nitrogen to any appreciable degree. To this he gave the name *Clostridium pasteurianum.*

Cultures of the latter were made in saccharine media free from combined nitrogen, in which the organism grew, apparently dependent upon the free nitrogen of the atmosphere for their food. The conclusion which the author reaches, however, is that the power of fixing nitrogen is not general among micro-organisms.

Since Winogradsky's investigations of the above, a few others have been isolated which are capable of fixing free nitrogen, notably, *Bacillus ellenbachiensis*, which is now sold in the form of cultures known as *alinit.*

The fact that but few species of bacteria possessing the power of utilizing free nitrogen have been found is no argument that they do not exist in the soil, and the fact that soils do make appreciable gains in nitrogen is indication that the necessary organisms must be present.

From a practical standpoint the matter has little significance, since the gains of soils from this source are in a single year inconsiderable as compared with those which can be so readily brought about by the growth of legumes.

To effect results of momentous importance their action must cover long periods of years such as have passed before the advent of European agriculture on the American continent.

8. The Use of Alinit.

All great discoveries are likely to lead to spasmodic efforts to revolutionize agriculture, and the climax has been reached in the effort to seed on soils with nitrogen assimilating bacteria by the use of alinit.

Alinit is a culture of *Bacillus ellenbachiensis*, which organism

is claimed to possess the power of utilizing atmospheric nitrogen. It is supposed to be particularly valuable in the growth of the cereals which lack the power of utilizing free nitrogen.

In the use of alinit, both beneficial and indifferent results have been obtained, but the experience in its use have not been as yet extensive enough to warrant definite conclusions being drawn regarding its value; but from a theoretical standpoint there is little to recommend it.

B. ellenbachiensis is probably identical with *B. megatherium** which is commonly present in soils, in which case nothing new is added to the soil by its use. Furthermore, of the myriads of bacteria present in a handful of soil, the addition of a relatively infinitesimal quantity of alinit would be like a drop of water added to a reservoir, and in the struggle for life between these myriads of soil bacteria there is a question whether one *B. ellenbachiensis* in a million other forms would be certain of a maintained existence, or at any rate be liable to multiply to a degree in excess of the others, sufficient to produce appreciable results.

If soil bacteria in general, as is probably the case, have any important relation to nitrogen assimilation, more is to be gained in following those methods already set forth, which aim to provide for the best development of soil bacteria in general.

At best, the gain of nitrogen from the use of artificial cultures, or from the stimulation of the development of any nitrogen assimilating bacteria already present, will be far below the demands of agricultural plants, and also inferior to the means which we have in the utilization of leguminous plants in our systems of rotation.

9. Recent Researches on Nitrogen Assimilating Bacteria of Soils (Oligonitrophiles.)

In 1901, Beijerinck† made a most important contribution to our knowledge of nitrogen assimilating bacteria of the soil. To this class of organisms he gives the name *Oligonitrophiles.*

To the oligonitrophiles belong two classes of organisms (1) the lowest microscopic algae, the Cyanophyceae and (2) the bacteria.

He showed that by seeding soils to solutions containing tap-water and K_2 H Po_4 and exposing the cultures to the light, an abundant growth of certain Cyanophycae would result, and that certain of these possessed quite active nitrogen assimilating properties.

By seeding soils into solutions containing potassium phosphate, carbonate of lime and some carbohydrate such as dextrose or mannit,

*Since the above was written, Severin has probably shown that B. *ellenbachiensis* is a distinct species distinct from B. *megatherium.* See Centralblatt f. Bakteriologie, 2 te. Abt. VIII. 1901.

†Beijerinck. Centralblatt f. Bakteriologie, 2 t Abt. VII. 1901. 562.

and protecting from the light, a growth began to develop on the surface of the medium composed of a peculiar large, round to oval celled organism, not unlike yeast cells, to which he gives the name *Azotobacter Chroococcum*. This latter organism Beijerinck found later on to bear a most important relation to nitrogen assimilation.

A little later Gerlach and Vogel* succeeded in isolating from garden soil the Azotóbacter of Beijerinck.

In the medium composed of dextrose 2 parts; patassium phosphate, sodium chloride, calcium chloride each 0.5 parts; and ferrous sulphate 0.1 part, they isolated and grew this organism in pure culture.

Analyses of the culture at seeding, and after three weeks growth showed a gain of 5.1 to 18.0 grams of nitrogen in 1,000 c. c. of culture. According to these investigators Azotobacter Chroococcum appeared to possess, when growing in pure culture in nitrogen free media, the power of utilizing free atmospheric nitrogen.

In a later communication, however, Beijerinck challenges this assertion, claiming that the cultures of the former authors were not pure cultures of Azotobacter, but mixed with other forms very difficult to separate.

Furthermore, Beijerinck showed that Azotobacter alone, in pure culture, was devoid of nitrogen assimilating power, and possessed it only when growing in symbiosis with other forms.

Beijerinck in his study of the Oligonitrophiles of the soil, or of those organisms which grow in media containing mineral salts and some carbohydrate such as dextrose or mannit, and therefore devoid or containing but a trace of nitrogen, isolated three types of bacteria—(1) The Azotobacter, with which is associated (2) several species of Granulobacter, and (3) Radiobacter.

The Azotobacter is a strict aerobe and grows only on the surface of the medium. It is what the author terms a macroaerophile.

The Granulobacter are large spore bearing bacilli of the Clostridium type, and when grown in saccharine media show the granulose reaction. They, therefore, belong to the same type as *Clostridium pasteuranum* of Winogradsky.

The Radiobacter, characterized by their polymorphic habit, and commonly radiate arrangement of the cells, are, possibly, closely related or identical with B. radicicola of leguminous root tubercles.

Both Granulobacter and Radiobacter while they do grow singly, grow best in symbiosis with Azotobacter.

Furthermore, both Granulobacter and Radiobacter singly possess only feeble or negative nitrogen assimilating properties, but when grown in symbiosis with Azotobacter there is a gain of nitrogen of from four to seven milligrams per gram of sugar, in the medium, assimilated.

*Gerlach and Vogel. Centralblatt f. Bakteriologie, 2 t Abt. VIII. 1902. p. 674.

Nitrogen assimilation, therefore, appears to be the work, not of a single organism, but of two or more growing in symbiotic relationship to one another.

Symbiosis is a term which has been frequently misapplied, it being confounded with mixed infection, and concurrent growths of two organisms. Mutual advantage should be the test of symbiotic relationship. Two organisms which grow together, grow symbiotically when they live to mutual advantage. An aerobe, or macroaerophile, in its greed for oxygen robs the medium of this element, and makes it better fitted for the development of an anaerobe. Thus B. *subtilis* and B. *tetani* may grow together in the same medium to their mutual advantage, or in symbiotic relationship. Frequently we do not understand in what this mutual advantage consists, although the fact exists as in the symbiotic relationship of clover to the root tubercle organisms.

Beijernick some years ago pointed out that certain organisms, while not strictly anaerobes, thrive best under a diminished supply of oxygen, or in other words, under diminished pressure of atmospheric oxygen.

These organisms he terms *Microaerophiles.*

If some form of Microaerophile be included in a hanging drop, the bacteria instead of grouping themselves at the periphery of the drop, as in the case with the aerobes or macroaerophiles, will keep within a circle some distance within the so called *respiration line* where there is diminished oxygen pressure.

Beijerinck showed that the Granulobacter are microaerophiles, and, as such, grow best when associated with some macroaerophilitic form like Azotobacter, which by its urgent demand for oxygen is capable of ridding the medium of that portion of oxygen which in its fullness would be unfavorable to the development of the Granulobacter.

Nitrogen assimilation, therefore, not only becomes a question of two organisms living in symbiosis, but of two organisms possessing distinct physiological properties; of Macroaerophiles with microaerophiles.

Whether their exact relationships are always necessary is, however, a question which may be reasonably doubted.

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SOME COMMON INSECT PESTS OF THE FARMER.

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The loss to crops caused by the attacks of insect pests is rarely appreciated. A quarter of a century ago even those who studied the subject considered this loss as being about one-tenth of the total crop. To-day this is recognized as being too low and estimates of fifteen, twenty and even twenty-five per cent. are often met with. Whether the earlier estimates were too low, seems doubtful, it being more probable that the actual amount of loss has increased with the increase of continuous acreage taken by man; by the introduction of over seventy-five of the worst pests of foreign countries; and by the decrease in number of our insectivorous birds. To-day every acre tilled, every fruit tree, every vine and every stalk of grass contributes of its substance for the sustenance of insects, and it is probable that before many years pass, every crop must be so treated as to prevent loss by their ravages, if any profit whatever is to be obtained.

Some of the most frequent and seriously injurious insects with which farmers in Pennsylvania meet are considered in this paper, and, in order to combat these insects intelligently, a knowledge of their lives is necessary; hence a brief outline of the life history is given in each case, in addition to the methods of treatment most generally found to be successful.

THE HESSIAN FLY.

(Cecidomyia destructor Say.)

The Hessian Fly is an insect which causes great loss to the wheat crop in Pennsylvania as well as in all the wheat raising States. This loss varies in amount from year to year; but is always considerable and may be as much as three-quarters of the entire crop.

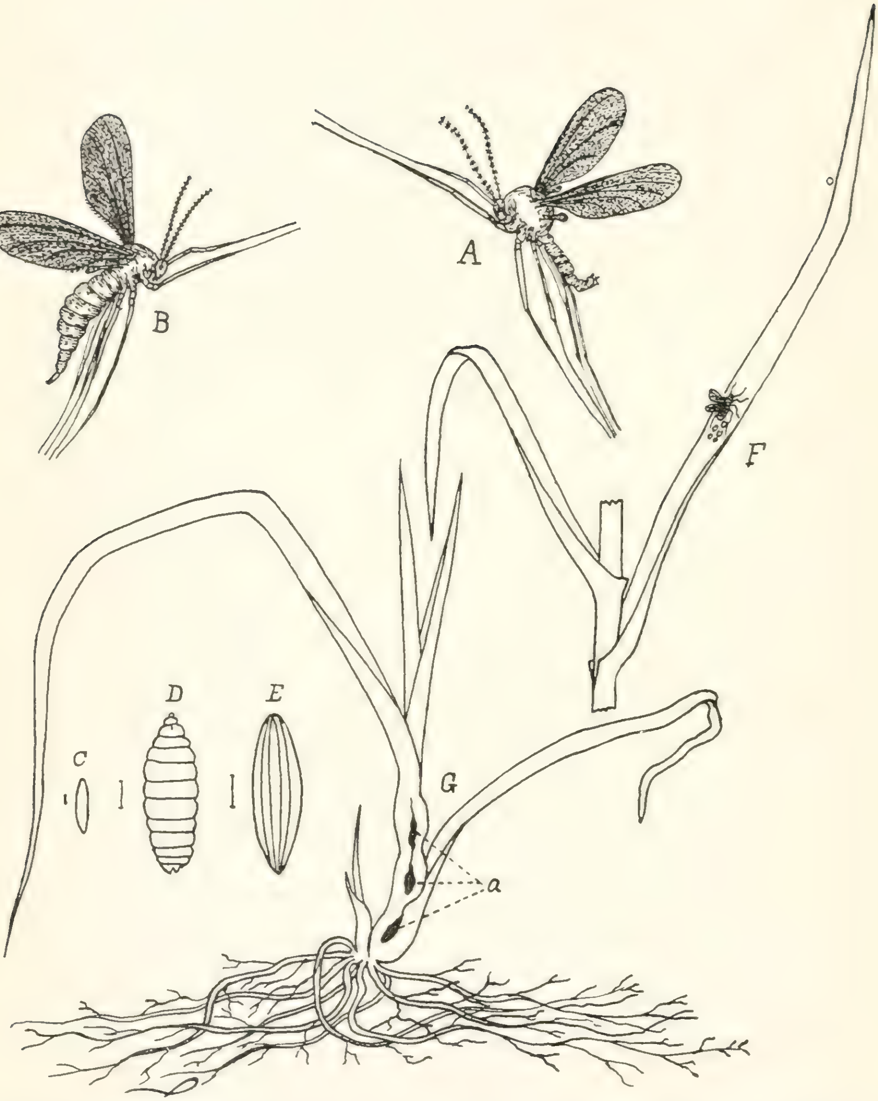


Fig. 1.—The Hessian Fly.—A, Male Hessian Fly, much enlarged; B, Female, also much enlarged; C, eggs; D, maggot; E, Flaxseed stage; F, piece of stalk showing fly, natural size, laying eggs; G, stalk of wheat injured at *a*, by the fly. The fine lines beside C. D. and E. show the true length of these stages, the drawings being enlarged.—(Modified from *Riley.*)

Life History.

There are two broods of this insect each year. The adult flies usually appear in August and September and lay their eggs on the leaves of the little wheat plants, placing from one to twenty-five or thirty eggs on a leaf and laying from one hundred to one hundred and fifty eggs in all (Fig. 1, F.). The eggs are very small, reddish, oval in outline (Fig. 1, C.), and usually hatch in four or five days, producing tiny white maggots which crawl down the leaf to the stem, then down between the stem and leaf sheath to the joint near the level of the ground. Here they remain, sucking the sap until cold weather comes, by which time they will have become about an eighth of an inch long (Fig. 1, D.). They then turn brown and become the well-known "flax seeds" so common in wheat fields during the winter. In this condition (Fig. 1, E.) they remain till spring when changes inside the "flax seed" produce the fly which escapes to lay eggs for the second or spring brood.

The eggs of this brood are laid as before on the leaves of the wheat, but usually higher than those laid in the fall, so that the maggots which hatch from these eggs lie above the ground level, just above the lower joints. Here they remain feeding for about a month, then enter the "flax seed" stage, from which the adult flies appear in August and September to lay their eggs on the young wheat plants which have newly come up.

The adult fly is about the size of a mosquito, with dusky wings (Fig. 1, A, B. F.).

Food Plants.

The favorite food plant of the Hessian Fly is wheat, though it also attacks rye and barley. In some cases it has been reported as working in hay fields, but this is probably incorrect. Winter wheat on which the maggots are feeding has much darker colored leaves than plants unaffected, and tends to stool out freely causing the plants at first to appear particularly healthy. Later, however, the plants turn yellowish and die either in part or entirely. Injury to plants in the spring is chiefly shown by a weakening of the stems and an at least partial failure of the grain on the affected stalks to fill out. The laterals—tillers—which escaped the attacks of the fall brood are usually the ones injured by the spring brood.

Enemies.

There are several insects which prey upon the Hessian Fly. Unfortunately, they cannot be relied upon to protect the wheat, but only to somewhat reduce the loss, and methods for checking the work of the fly are also necessary.

Treatment.

There are several ways in which the injuries caused by the Hessian Fly may be reduced, though no one of these is of itself sufficient to give entire protection.

Late fall planting is generally a method of control which is quite successful. The flies appear during the latter part of August and first of September and by the last of the latter month have died. If the wheat be planted as late as the twentieth of September, therefore, the flies will be gone before it has come up and no eggs will be laid upon it in most cases. Unfortunately, however, this date is not a fixed one for different latitudes and elevations. In southeastern Pennsylvania it might be necessary to delay planting for a week or more after this date, while in the higher lands of the northern parts of the State sowing could perhaps begin as early as the tenth of the month with success.

The fear that wheat sown as late as the twentieth of September will suffer the following winter is practically groundless, as a large amount of growth is unnecessary, for the above ground portions are mostly destroyed in any case.

One factor bearing on the date at which wheat should be sown to escape the attacks of the fly, is that of the weather conditions. A hot, dry August seems to delay the fall brood of this insect, which accordingly appears later than usual and is able to attack the late sown wheat. This was noticeably the case in Pennsylvania in the fall of 1900, and in some cases at least, threw discredit on the plan of late planting.

If sowing after the twentieth of September be practiced, it is quite important to have co-operation with all wheat-growing neighbors. If ten or a dozen wheat-growers should agree to plant late, and one should refuse, the fly will find abundant opportunity to lay its eggs on the wheat of the latter and thus produce a supply of insects which will, the following spring, spread to the surrounding wheat fields and lay their eggs for the spring brood, thus rendering late planting the previous fall a failure, at least in part.

A trap strip of wheat planted early in August is an excellent, but too seldom used, method for controlling this insect in connection with late planting. Such a small strip sown along one side of the field which is to be planted later will be available for the flies to lay their eggs on, and after egg laying has been accomplished the flies very soon die, or if they should live would of course no longer be dangerous to the main crop. This trap strip should be plowed under before the wheat in the field comes up, thus destroying multitudes of the young.

Burning the stubble soon after reaping is a valuable treatment, as

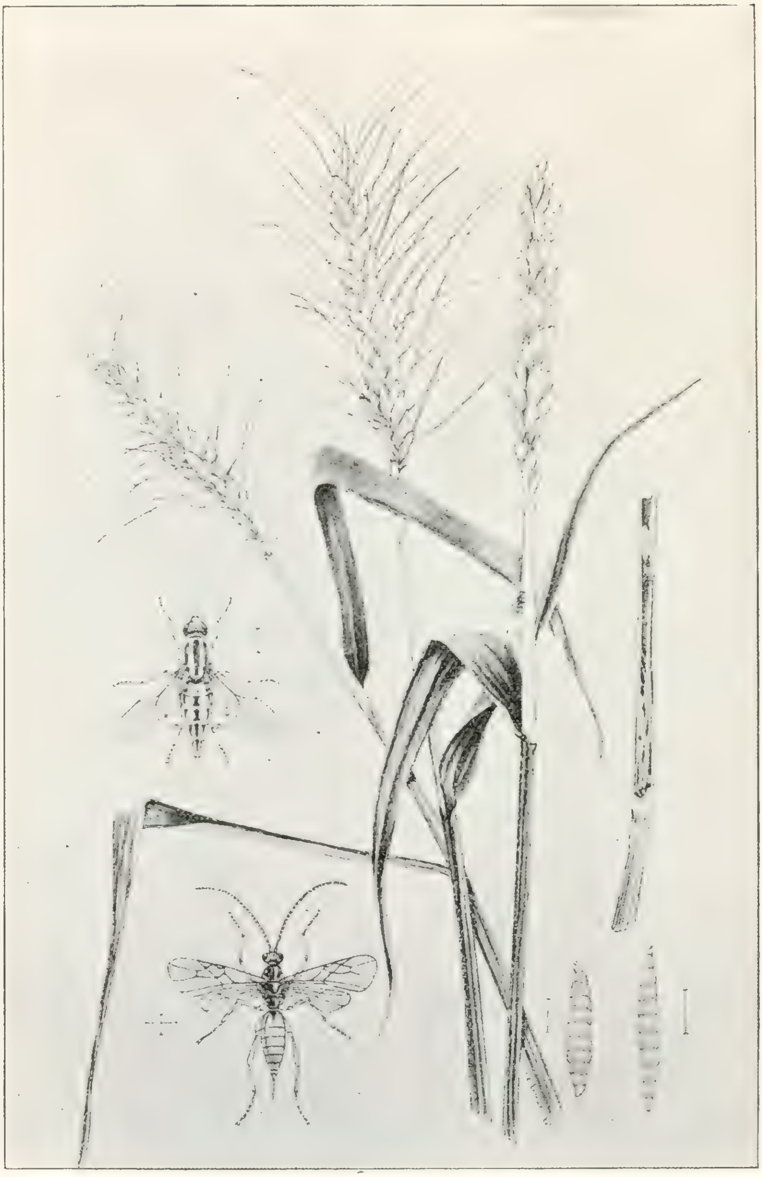


Fig 2.—The Wheat-stem Maggot. Adult fly above at left; injured stalks of wheat; piece of stalk split open showing maggot at work; maggot enlarged, and a parasite. Fine lines beside the figures show the true length. (From *Lugger.*)

the spring brood of the fly develops at the lower joints of the wheat and a great many "flax seeds" of this brood will be left in the field at harvesting time. Turning the stubble under is also of value where burning it would be difficult, provided the ground be then rolled so that the flies which come from the "flax seeds" will be unable to reach the top of the ground. Some varieties of wheat are more resistant to the attacks of the fly, than others. Among these are the Clawson, Mediterranean, Red Cap, Underhill, Dawson's Golden Chaff and Prosperity.

The destruction of volunteer wheat is important, as many flies pass the summer in such plants.

THE WHEAT-STEM MAGGOT OR WHEAT BULB-WORM.

(Meromyza americana Fitch.)

The wheat-stem maggot has long been known as an enemy to wheat in Pennsylvania, but its habits and injuries so nearly resemble those of the Hessian Fly, that its work is usually supposed to be that of the latter insect by those not familiar with it.

Life History.

This insect attacks wheat, barley, oats and various grasses. The adult fly deposits its eggs on the wheat in September and October and the maggots which soon hatch crawl down to some joint near the bulb and feed upon the stalk, cutting it off. They pass the winter in the stem, become quite pupæ in April or May and the adults emerge from these pupæ early in June. These adults usually deposit eggs on the sheath of the upper leaf and the maggots which hatch from them feed on the stem near the upper joint, causing it to wither, and the heads to turn white. The adults produced from these maggots appear in July and early August and their young attack timothy, blue grass ,volunteer wheat, etc., and mature in time to produce adults which deposit their eggs in September and October, as already stated, on the young winter wheat. There are, therefore, three broods each year.

Treatment.

Little that is successful has yet been discovered in the way of treatment for this insect. Late planting is useless as the insects may lay their eggs as late as the middle of October. The summer brood is probably the best place in the life of this insect at which to attack

it. This brood feeds on volunteer grain and grasses and if a trap strip of wheat were planted about the fifth of July it would provide a place for the insects to lay their eggs. This trap strip should be plowed under about the middle of August thus destroying all the insects which were in it. Whether this treatment will pay, however, can only be determined in each case by the amount of loss caused by this insect.

Fortunately, the wheat-stem maggot is not without enemies which attack it in such numbers as to prevent its injuries being far more serious than is usually the case.

THE ARMY WORM.

(Heliophila unipuncta Haw.)

This well known pest preferably feeds upon grasses, and wheat, oats and corn are therefore favorite articles of food. As it is not limited to these food plants, however, it frequently is seriously de-

Fig. 3.—The Army Worm Moth, natural size.

structive to clover, peas, apples, cucumbers, barley, rye, etc. With such a range of plants to feed upon, it is fortunate that this insect is not often seriously abundant for more than a year or two at a time.

Life History.

The eggs of the Army worm are laid in the spring and the caterpillars which hatch from them become adult moths in June. These moths lay their eggs for a second brood and the caterpillars of this brood are often so abundant as to do much damage during the month of July. About the end of this month, however, the caterpillars become full grown, cease feeding, enter the ground to pupate and the moths which emerge from them appear in August and lay eggs for a third brood. The caterpillars of this brood are sometimes so

abundant as to cause much injury, but it is more usually the case that those of the second brood are the ones whose ravages are most seriously felt. The caterpillars of the third brood usually reach the moth stage before winter, but those which fail to develop so far, pass the winter in whatever condition they may happen to be and become adult the following spring. It is possible that in southern Pennsylvania a fourth brood may be able to develop, particularly in years when there is a late fall.

Injuries.

The first brood of caterpillars does but a moderate amount of damage, eating holes in the leaves. When the food available has all been eaten, the caterpillars search for more, starting off together and forming the "armies" which have given to this insect its name. This almost never occurs with the first brood, however, and only at intervals of several years with the second or third broods, the insects not being usually so abundant as to exhaust their food supply. Upon reaching food, the caterpillars begin their work and strip everything as they go, and when full grown, either under ground or among leaves and grass, become quite pupæ from which the moths subsequently emerge.

Parasites and Treatment.

The Army worm has a number of parasites which feed upon it and their activity is probably the reason why this insect is not more often a serious pest. Among its most efficient foes are two kinds of flies which occur in large numbers where the Army worm is abundant.

Parasites, however, sometimes fail to destroy enough Army worms to prevent much loss, and in such cases, treatment must be resorted to. Where a field is thoroughly infested by these pests, little can be done, but when the caterpillars begin their march for more food, an excellent practice is to plow a furrow across their line of march, throwing the earth towards the advancing army. In order to cross this furrow each caterpillar must crawl over the loose earth thrown up, then cross the bottom, and finally crawl up the steep side. At intervals of a few feet along the bottom of the furrow, holes may be dug (or bored with a post hole auger if the ground will permit) and many of the caterpillars will collect in these holes, which may with advantage be made as much as two feet deep. A band of gas tar placed along the bottom of the furrow may be used to hold the caterpillars, when it can be obtained, and sometimes straw scattered along in the furrow and set on fire when covered by the cater-

pillars has proved useful. When the army is large, two furrows a few feet apart may be needed to check its advance.

Sometimes the progress of the caterpillars can be checked by heavily spraying a strip of field at the edge they are approaching, with Paris green. The insects coming to this strip first, feed upon it and are poisoned. Care should be taken, however, in such cases, not to feed any of that part of the crop thus sprayed, to stock.

WIRE WORMS.

(Elater sp.).

The injuries caused by wire worms are frequently quite serious, and as the work of these insects is upon the roots of plants it is difficult to control them. In reality, wire worms are not adult insects, but the young of "Snapping beetles" or "Click beetles" as they are

Fig. 4.—Wire Worms. B, side view of a wire worm; A and C. adult of wire worm (click-beetles).

often called, from the habit they have when placed on their backs, of suddenly "snapping" themselves in such a manner as to throw themselves into the air, when they in most cases can fall on their feet.

There are many kinds of snapping beetles in the United States and a corresponding number of kinds of wire worms, their young. A few live under the bark of trees or in decaying wood; most, however, live in the ground and feed upon seeds and the roots of various plants, often causing much loss.

Life History.

The eggs of these insects appear to be laid in the spring usually and from them the little wire worms soon hatch and begin to feed. It generally takes several years before the little wire worms have fed enough to become full grown, but when this condition has been reached each forms a little cell in the ground, during the latter part of the summer, and in this cell changes to an adult snapping beetle, which remains in the cell till the following spring.

Treatment.

Treatment for this pest is not usually possible by means of poisons though in some cases their numbers might be reduced by such methods.

Probably the best way in which to control wire worms is by late fall plowing, repeated for two or three years. This destroys the wire worms by bringing them up to the surface of the ground where exposed to the freezing and thawing of the winter, many will perish or be devoured. Breaking the cells above described appears to cause the death of the insects which occupy them, and thus fall plowing is useful for the destruction of this stage as well. Rotation of crops is unfavorable to the increase of wire worms and should also be practiced for this reason if for no other.

THE ANGOUMOIS GRAIN MOTH.

(Sitotroga cerealella Oliv.)

This insect is an important enemy to wheat and corn in Pennsylvania, often causing much loss, particularly when appearing during the fall after the attacks of the Hessian Fly have greatly reduced the amount of wheat produced.

The Angoumois grain moth has been present in this country for many years, being most injurious in the south where the longer seasons permits a greater number of broods than is possible in northern latitudes. In Europe it is also a pest and takes its name from a province of France where it has caused much loss.

Life History.

The moth of this insect is very small, about the size of the clothes moth, and yellowish in color. It appears in the spring, usually during May and June, and lays from sixty to ninety eggs. These are laid separately and if on wheat, are placed in the furrow on the side of the kernel itself, one on each grain. The little caterpillar which hatches from the egg bores into the grain and feeds upon its contents until it is full grown, this process requiring about three weeks. At the end of this time the caterpillar is about one-fifth of an inch long and little of the grain is left except an outside shell. The caterpillar now cuts a part of a circular slit in this shell, leaving just enough of the circle uncut to hold the piece in place, and then forms a

silken cocoon around itself within the grain. In this cocoon it transforms from the caterpillar to the moth and when this change has been completed the moth pushes out the circular piece cut by the caterpillar in the surface of the grain, and escapes. This usually occurs in August, and the moths, therefore, find themselves either in the stack, when threshing has not yet been completed, or wherever the grain has been stored. They now proceed to lay the eggs for a second brood which has a similar history. The work of this brood, like that of the first, is generally overlooked until the moths appear, at which time the abundance of the little "millers" around the bins and granaries, and the holes in the grains become noticeable. If the temperature of the place where the grain is stored be high enough, the moths lay their eggs for a third brood and if conditions permit will continue breeding through the winter. Usually, however, in Pennsylvania but two broods occur, and the insect passes the winter in whatever stage it happens to be when cold weather overtakes it.

Parasites and Treatment.

There are two foes to the Angoumois grain moth in Pennsylvania —a mite, and a minute insect known as *Catolaccus.* The latter has been quite abundant in this Commonwealth and has prevented some loss, but has failed to control the grain moth. Treatment should therefore be resorted to.

For the first brood of the grain moth nothing can be done as the insect is working inside the grain while it is yet uncut in the fields. After harvesting, however, the second brood can be cheaply and easily handled.

In order to successfully treat the grain at this time, it is desirable to thresh it as soon as possible after harvesting. Then when the grain has been placed in the bins it can be fumigated with carbon bisulfide and all the insects destroyed.

To properly use the carbon bisulfide, the following directions should be followed: See that the bin is tight and that it can be closed so as to be fairly tight at the top, though this is less important. Place shallow dishes on the top of the grain and pour the carbon bisulfide into these; then close the bin and leave it undisturbed for twenty-four hours, after which the cover may be lifted and the bin left to air for an hour. Now stir over the grain to find if all the insects have been killed, and if any remain (which is not usually the case) repeat the treatment.

The quantity of carbon bisulfide to use depends on the size of the bin, the usual amount being one pound (costing twenty-five or thirty cents) to every thousand cubic feet contained in the bin. Thus one pound would be sufficient for a bin ten feet wide, ten feet long and

ten feet high, and the amount of grain contained in it does not matter. To advantageously use the bisulfide in a bin, it may be divided between several dishes set on top of the grain, and as it begins to pass off as a gas into the air at once, the lid should be closed as soon as the bisulfide has been placed in the dishes. The gas it forms is heavier than the air and sinks through the grain, killing all the insects it reaches.

Two precautions in using this method should be mentioned. Avoid breathing the gas as far as possible as it is very disagreeable and in sufficient amount might be injurious. Avoid using the gas near flame or much heat of any kind as it catches fire easily and a lighted pipe in the mouth of a workman close by, or a lighted lantern within a few feet of the bin during the time treatment is going on might produce serious results. No injury of any kind is caused to the grain by this fumigation, and seed wheat seems to be as good for sowing afterwards as before.

This method of fumigation is also excellent for the destruction of the pea and bean weevil and other insects, and can also be used for the destruction of insects in cereals, meal, ground tobacco, and in fact in anything which can be placed in a box or bin tight enough to prevent the escape of the fumes of the bisulfide for a period of a day or more.

THE CODLING MOTH.

(Cydia pomonella Linn.)

The Codling moth is perhaps responsible for more of the loss to our apple crop than any other insect. Its caterpillar, generally called the "apple worm," begins its attack soon after the fruit forms in the spring and destroys multitudes of apples before they are more than one-third grown. These are seldom taken into consideration, only those which are wormy later in the season being noticed. But these form a large proportion of the gathered crop where no treatment for the control of this insect is carried out, and the loss in the form of second or third class, where first class fruit could otherwise be obtained, reaches millions of dollars nearly every year—a loss which is wholly unnecessary as it can in large measure be avoided.

Life History.

The Codling moth spends the winter in the caterpillar stage snugly hidden under some loose piece of bark on the trunk of the apple tree or in equally protected places near by. In April usually,

the caterpillar becomes a quiet pupa the skin of which is dark brown, and in this form remains for two or three weeks. At the end of this period the pupa opens and the adult Codling moth appears soon

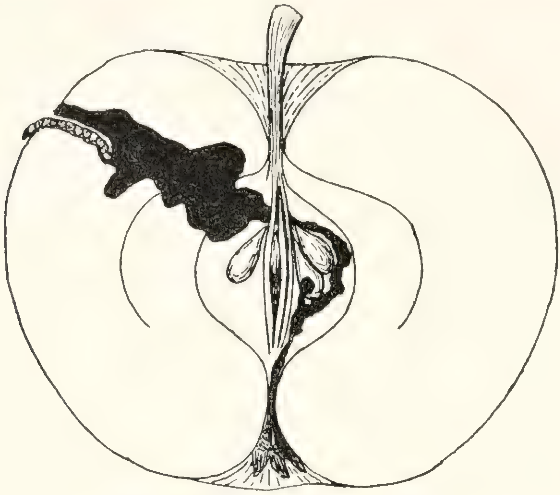


Fig. 5.—Apple, cut to show work of Codling Moth, with caterpillar leaving, at the side. Natural size.

after the apple blossoms have fallen and the fruit which has "set" is beginning to enlarge. The eggs are now laid, one in a place, on the side of the apple, on its stem, or on a twig or leaf near by, a single moth laying between fifty and a hundred eggs. These eggs hatch in about a week and the tiny caterpillars crawl to the fruit to begin feeding. Probably about eighty out of every hundred of these caterpillars enter the apple at the blossom end which now faces upward or outward, but which as the apple grows larger will turn down with it until it is beneath the apple. Here at the blossom end of the fruit the caterpillar crawls in between the five little green projections (calyx lobes) which later dry up and turn black, and begins to eat into the substance of the apple, usually working to and around the core where it feeds for nearly a month or until it is full grown. It then eats its way to the outside of the apple and leaves it to find a place in which to become a pupa. If the apple it has fed in be still on the tree, the caterpillar on leaving it will probably crawl down the trunk until it finds a piece of loose bark beneath which it can crawl. Here it gnaws out an oval hollow in the bark, lines it with silk and becomes quiet. If the apple has fallen, however, any protected place the caterpillar can find will be taken in which to form its silk cocoon. This change usually occurs during July and the caterpillar may either remain quiet until the following spring, or in some cases become a pupa from which the adult moth soon comes to lay eggs for

a second brood. It is probable that both of these alternatives occur in Pennsylvania, some of these insects having two broods each year while others have but one. In cases where there is a second brood the eggs are laid in August or September, and the caterpillars feed as is the case with the spring brood except that a much smaller proportion appear to enter the fruit at the blossom end. If the caterpillars reach full growth before the apples are gathered they leave the fruit and conceal themselves under bark or elsewhere as already described. If carried in the apples to the bin, however, they find places in which to pass the winter, in crevices of the bin, or any place which may be available, forming pupæ there in the spring, like the others.

Treatment.

From the life history above outlined, the best treatments available for this insect are evident. As the majority of the caterpillars feed first at the blossom end of the apple, and as these ends face upward at this time, spraying a few days after the blossoms fall, with Paris green or arsenate of lead, will, if properly done, place a little of the poison in the blossom end between the calyx lobes, just where the caterpillars will begin to feed. This method of treatment has been successful wherever tried. One precaution is necessary, however. The calyx lobes at first stand apart, making a sort of cup into which to spray the poison. After a short time, however, they draw together closing this cup and it is then too late to spray in this manner with success.

The habit the caterpillar has of crawling down the trunk of the tree and hiding under some loose piece of bark during July, also gives an opportunity for treatment. The bark of the trunk and larger limbs of each tree should be carefully scraped about the twentieth of June, to leave no places under which the caterpillar can hide. Then a band of several layers of paper loosely tied around the trunk will provide a place in which they may gather. If these bands be turned over once a week during July and the first of August, and the caterpillars destroyed, many will be prevented from becoming adult to cause loss later. Birds aid in this work, often regularly visiting these bands and feeding on the caterpillars.

Fowls in the orchard destroy many of the caterpillars which have fallen to the ground in the fruit; careful cleaning of the apple bins and other places near where apples have been stored, early in the spring, will destroy many more, and if all these methods are made use of, the increased profit from the sales will many times more than pay for the cost and labor involved.

THE APPLE-TREE TENT CATERPILLAR.

(Epicnaptera americana Harr.)

This familiar pest on our apple trees is of importance only when neglected, as its presence becomes evident at an early stage. It feeds on the cherry, plum, peach and wild cherry as well as on the apple, and its tents at once call attention to its presence whenever they appear. It should be remembered, however, that the tents of

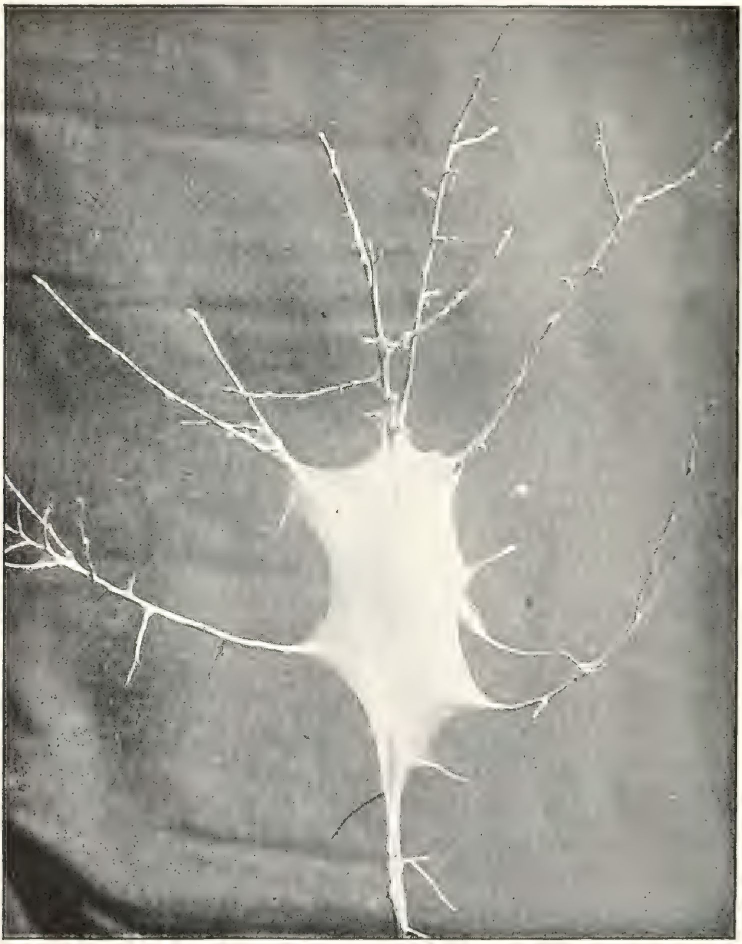


Fig. 6.—Tent of Apple-tree Tent Caterpillar. On the lower branch at the right is the egg mass from which the caterpillars hatched.

this insect appear in the spring, while similar ones which become noticeable in the summer and fall are produced by other kinds of insects.

Life History.

The eggs of the apple-tree tent caterpillar are laid in July in the form of a ring or band around some small twig, each band containing from one hundred to three hundred eggs. At the edges the band which is half an inch or more in width is beveled down to the twig. The whole band is then covered by a brownish substance which hardens and forms a sort of varnish which conceals the individual eggs beneath.

The egg bands remain on the twigs from July until the leaf buds begin to open the following spring. At about this time, however, the eggs hatch and the little caterpillars crawl to some fork near by where they spin a tent, small at first, but enlarged from time to time as the caterpillars grow. From this tent the caterpillars go to feed, mornings and afternoons, returning to it at night, and in part, at least, about noon. Most of them also stay in the tent during rainy weather.

The caterpillars feed for five or six weeks before becoming full grown. As this condition is reached, each leaves the tent to find some protected place in which to spin a loose silken cocoon, within which it transforms from the caterpillar to the adult moth, a process requiring from two to three weeks. This change having been completed the moth appears sometime in July, and the eggs are laid from which caterpillars will appear the following spring. There is therefore but one brood a year.

Injury.

The amount of injury caused by this insect varies with its abundance. A full grown caterpillar will eat about two leaves a day and one tentful will therefore consume from two to six hundred leaves in this time. Averaging this rate of food consumption for the entire time they are feeding, we find that a tent containing two hundred caterpillars will consume over four thousand leaves in all. A vigorous tree would probably feel this but little, but a small tree, or a large one with a number of tents on it would be obliged to turn its energies to the putting forth of new leaves to take the place of those lost, just at the time when those energies should be devoted to the maturing of its fruit.

Treatment.

The treatment for this insect is simple, the fact that the caterpillars return to the tents at night making it easy to destroy these when all the caterpillars are together, either by means of a torch held under the tent, or better, by crushing tent and caterpillars with a gloved

hand. In using the torch many of the insects drop to the ground and escape, while the flame is injurious to the tree—both being objections avoided by the other method. Spraying the tree with arsenate of lead or Paris green when the tents appear is also a successful treatment.

The eggs masses are often very noticeable, particularly while the trees are leafless, and should be cut off and burned, and every fruit grower should see that no tents of this insect should be permitted on the wild cherry and other trees along the roadsides near his orchards, unless he is prepared to find them present on his fruit trees the following spring, as a result. The continued presence of this insect in an orchard is evidence of neglect.

THE ROUND-HEADED APPPLE-TREE BORER.

(Saperda candida Fab.)

This insect is "next after the codling moth, the worst enemy to apple culture in America." The greater portion of its life is spent beneath the bark of the tree where it is only accessible to its enemies in a limited degree.

Fig. 7.—Round-headed Apple-tree Borer. A, Adult Beetle; B, full-grown grub. Both enlarged.

Life History.

The adult beetle which is rarely seen is about three-quarters of an inch long, grayish in color, and with two white stripes along its back. It lays its eggs during June, July and August in slits in the bark, usually near the ground. The young beetles which hatch in two or three weeks after the eggs are laid, bore into the inner bark and sapwood where they feed, making shallow cavities, often so near

the surface that the bark over these cavities cracks and some of the "sawdust" falls out. During the winter the borers are quiet, but resume their work the following spring. During this second year they work deeper into the tree, boring in the heart wood, but at the approach of winter become quiet again. The next spring they bore out to the bark and then become quiet pupae for a short time, after which the adult beetle formed from the pupa during this stage gnaws through the thin layer of bark left over the hole and escapes.

Food Plants.

This borer works in the trunks of the apple, pear, quince, thorn, English hawthorn, Mountain ash, June berry and other trees.

Treatment.

To prevent this insect from laying its eggs on the tree, a wrapping of several thickness of paper may be placed closely around the trunk. The paper should be covered by a little earth at the bottom and reach up about two feet, and be closely tied, so that the beetles cannot get between it and the trunk. The wrapping should be applied about May 10th and remain at least until September.

Wire window-screen netting can also be used for this purpose, care being taken that the lower edge of the netting be covered by the earth, and that some little space is left between it and the trunk except where it is fastened tightly around the tree about two feet above the ground. A protector of this kind will last for several years and if properly applied in the first place, will need no attention.

Either of these methods will protect the lower part of the trunk; but as the beetle sometimes lays its eggs higher up, it is advisable to whitewash the trunk from the lowest fork down to the top of the protector at the time when this is put in place.

When borers are already in the trunk, their presence may often be discovered by the accumulation of sawdust around the base. In such cases the insects may be cut out with a knife, or if they are too far in to be conveniently reached in this way, a sharp-pointed flexible wire may be used with which to follow the hole and pierce the borer. Frequently when the burrow can be found, the most convenient treatment is to pour a little carbon bisulfide on some cotton, place the cotton in the hole and then plug up the hole outside, leaving the fumes of the gas to kill the borer.

THE PLUM CURCULIO.

(Conotrachelus nenuphar Herbst.)

The plum curculio is the cause of more loss to plum growers in this State than all other insects combined, fifty, sixty or even seventy-five per cent. of the plums often being destroyed by its attacks. Quite a part of this loss can be avoided, however, by using the proper methods, while if these are neglected the insect as it becomes more abundant in an orchard will also attack apples, pears, cherries and peaches, injuring the appearance of these fruits and thus lessening their value, even when it does not prevent their reaching maturity.

Life History.

The plum curculio in its adult state is a little beetle about a quarter of an inch long, dark in color but with a few whitish markings on its roughened back, and with a snout on its head. It passes the winter hiding in any protected place it can find, and makes its appearance about the time the leaves open in the spring. While waiting for the plums to form, it feeds on the young leaves somewhat though doing little damage in this way, but when the blossoms have fallen and the plums have begun to grow, it proceeds to lay its eggs. To do this, it makes a small hole in the plum with its snout and in this hole it deposits an egg. It appears to realize, however, that unless farther precautions are taken, the rapid growth of the hard young plum will crush and destroy the egg, and it therfore cuts a crescent-shaped slit near where the egg was placed. The result of this is that the flesh of the plum between the egg and the slit wilts and remains soft, and crushing of the eggs is thus prevented. Each curculio lays from fifty to one hundred eggs in this way and plums with six or eight slits and egg holes are frequently observed.

The eggs thus laid soon hatch and the young grubs eat into and around the stone, while the surface of the plum where the slits were made becomes gummy.

Around the stone the grub feeds till it is full grown, the time required for this being usually about three weeks. The grub then leaves the plum (which frequently falls off before this time, because of the presence of the grub) and enters the ground where it becomes quiet and transforms to a pupa from which the adult curculio appears a month of more later. Apparently this curculio does no injury during the remainder of the summer and fall but appears after wintering in some secluded place, to lay its eggs the following spring.

Treatment.

No one method of treatment is sufficient for this pest, but if the three given below be practiced, much loss will be prevented.

1. It has already been stated that in the spring the adult curculios feed on the young leaves until the plums have begun to grow. This fact may be taken advantage of by spraying the trees with Paris green, or better, with arsenate of lead just before the blossoms open, and repeating this treatment as soon as the blossoms have fallen. Do not spray while the trees are in blossom.

2. The adult curculios during the time they are feeding and laying their eggs, are sluggish mornings and evenings, though they will fly freely during the heat of the day and also on warm nights. This habit is successfully utilized by plum raisers who spread out sheets under the trees early in the mornings and then jar the trees by striking the trunks with a heavy mallet. The curculios fall onto the sheets and are gathered and destroyed. An improvement on this is to stretch canvas over a frame having sloping sides, and at the center opening into a tin can containing a little kerosene. A slit from the middle of one side to the center is not covered by the canvas but is left open so that the trunk of the tree may pass in through this to the center of the frame. A strip of canvas sewed to one side of the slit is then turned over to cover it and the canvas completely covers the ground under the tree. Such a frame mounted on a wheelbarrow can be conveniently and rapidly used and the curculios which fall upon the canvas when the trees are jarred, roll down the sloping sides of the frame and into the can of kerosene in the center. Plum orchards of hundreds of trees are every year treated in this way with great success, the trees being jarred every other morning.

3. The above methods will prevent multitudes of the curculios from laying a part or even any of their eggs, but it is equally important to destroy as many as possible of the grubs coming from eggs which have been laid. As a large proportion of the plums which have been "stung" by the curculios drop early, and as these grubs are readily eaten by fowls, it is advisable to let poultry and also hogs run freely in the orchards, or if this is not practicable, to gather the fallen plums and destroy them twice a day if possible, beginning about a week after the second spraying.

THE PEACH-TREE BORER.

(Sanninoidea exitiosa Say.)

The Peach-tree borer is one of the most serious enemies with which peach growers in this country have to contend. Much attention has recently been paid to this insect and many experiments have been

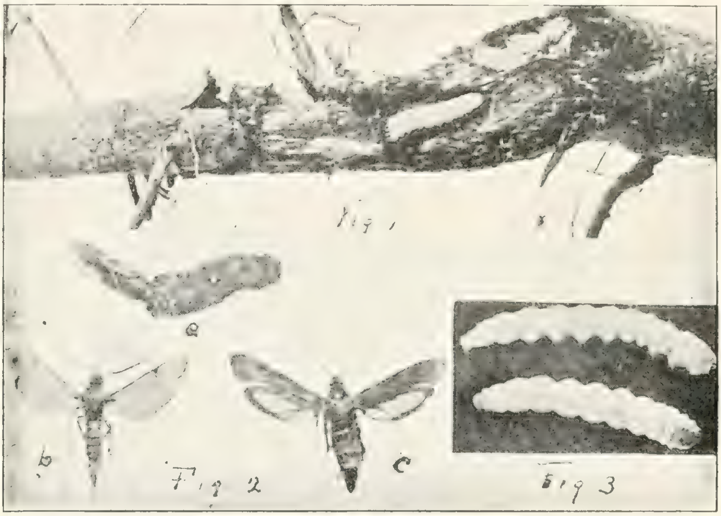


Fig. 8.—Peach Tree Borer. Plum root showing work of borer; 2 a, pupa case; b, male moth; c, female moth; 3, two grubs somewhat enlarged (From *Sirrine.*)

made with a view to protecting the trees from its attacks, the results of which have somewhat changed our ideas as to the best methods to follow.

Life History.

The adult borer is a rather pretty, clear-winged moth, rarely seen by the peach grower. It appears in Pennsylvania early in June and lays its eggs on the bark of the peach tree, preferably near the ground, though they are sometimes placed as far up as the crotches of the lower branches. The egg soon hatches into a little grub which eats its way through the bark to the sapwood where it lives till fall, its feeding causing the production of masses of gum on the bark just outside where the borer is at work. At the approach of winter the grub ceases its work, but resumes operations again the following spring, and feeds until about the last of May or until it is full grown, when it is about an inch long. It then forms a quiet

pupa which changes to the adult moth and leaves the tree early in June to lay its eggs for the next generation.

Treatment.

More than twenty different methods of treatment for this insect have been tested at different times, most of them proving of little value. Only those which have given the best results are considered here.

Mounding.—This treatment seems to be quite effective, keeping out "from one-half to seven-tenths of the borers." The earth should be mounded up around the trunk of the tree to the height of a foot or more, about the first of June, and should remain there till about the last of August, each year.

Paper Protectors.—These may be either of tarred paper or of several thicknesses of newspaper. The paper should be closely wrapped around the trunk, the lower edge of the wrapping being covered by the earth, and the upper edge being at least fifteen inches from the ground. The times of applying and removing the wrapping should be the same as for mounding.

Cutting Out.—This treatment is of course remedial rather than preventive and should be used together with the other methods given. It is desirable to cut out the borers in the fall before they have done much damage, but they are so small at that time that many are always overlooked, and it is therefore better practice to do this work about the first of May when the borers are large enough to be easily found. If cutting out each spring be followed by mounding or by wrapping the trunks as already explained, much of the loss by the attacks of the peach-tree borer can be prevented.

THE PEACH-TWIG BORER.

(Anarsia lineatella Zell.)

This insect is very abundant in Pennsylvania and does much damage though its presence is in most cases unknown to the peach grower, who, for this reason, is not aware of his loss from the attacks of this tiny moth.

Life History.

The little caterpillars of the peach-twig borer pass the winter in the spongy bark, chiefly of the smaller crotches of the tree, in small cavities they hollow out and which are marked by small masses of

mixed bark and excrement projecting from the openings of the cavities. In the spring the caterpillars leave these cavities and pass to the leaf buds which they bore into, following along in the stem bearing the bud, eating its substance and causing the leaves to wilt and die. At this time their presence may be discovered by looking for the wilted tufts of leaves which are very noticeable among the others not thus affected. After boring out one shoot the caterpillar passes to another which it destroys in the same way, and it may attack several before becoming full grown. When the caterpillar has reached full size, it forms a small web either in withered leaves on the tree, in leaves or rubbish around the tree, or it may lie exposed on the bark. In either case it now remains quiet for a week or ten days, at the end of which time the internal changes necessary having been completed, the adult moth appears and lays eggs for a new brood. The caterpillars which hatch from these eggs attack new growth of the tree, entering the young twigs where these give off leaves, or sometimes entering the stems of the young fruit, and later, in some cases, boring into the fruit itself. This history is probably repeated by the next brood, and in the fall the eggs for the third brood are probably laid on the bark and the little caterpillars burrow into the bark to pass the winter. There are therefore three broods each year.

Injuries.

The spring brood which passes the winter in cavities in the bark at the crotches, is the one which is most noticeably injurious. As it bores into shoot after shoot in the spring, the number of these which are killed when the insect is abundant is very great, often several hundred of the young shoots on a single tree being destroyed. The result of this upon the tree is to make it scraggy and irregular and to cause it to expend its energy in the formation of new growth at a time when this energy should be devoted to the production of fruit.

Treatment.

The best method of control for this insect which has as yet been found, is to spray the trees in winter to destroy the caterpillars which are then in cavities in the bark at the crotches.

To successfully carry out this method it is advisable to lightly scrape the larger crotches with some blunt edged instrument—a hoe has been found to be well adapted to this purpose. After scraping in this way the tree should be sprayed with kerosene emulsion, made and applied as follows:

Kerosene, ...	2 gallons.
Whale-oil soap, ...	$\frac{1}{2}$ pound.
Water, ...	1 gallon.

"The soap, first finely divided, is dissolved in the water by boiling and immediately added boiling hot away from the fire to the kerosene. The whole mixture is then agitated violently while hot, by being pumped back upon itself with a large force pump and direct discharge nozzle throwing a strong stream, preferably one-eighth inch in diameter. After from three to five minutes pumping the emulsion should be perfect and the mixture will have increased from one-third to one-half in bulk and assumed the consistency of cream. Well made, this emulsion will keep indefinitely, and should be diluted only as wanted for use." To use it, add six gallons of water to a gallon of the emulsion or at that rate. If hard water must be used either in making or in diluting the emulsion for use, add about one-quarter more soap. Spray long enough to thoroughly wet the bark, but not long enough to let the emulsion stand in the crotches in little pools as this would have an injurious effect upon the tree.

PLANT LICE.

(Aphididae.)

Plant lice or Aphids are always an important pest to crops and to flowers as well. They appear early in the spring, often before the plants they feed upon have made a good start, and as they multiply with great rapidity, sometimes cause much loss.

Nearly every plant, shrub and tree has one or more kinds of plant lice which attack it, and in seasons favorable to their rapid increase may so check growth as to seriously injure the crop.

Among the most important plant lice with which the farmer and fruit grower come in contact are the wooly apple louse, often present along scars on apple limbs in the fall, and very noticeable because of the white wooly threads it produces; the green apple louse, often so abundant in spring on the leaves; the black louse on the plum; the wheat Aphis; the pea-vine louse; the cabbage louse; the currant louse; the rose louse and the corn Aphis.

In many cases the first evidence of the presence of plant lice is the curling of the leaves which is often particularly noticeable on cherry and plum trees in May. Often, however, the plant lice are not seen in large numbers till later, in the summer or even fall.

Life History.

No accurate description of the life history of plant lice in general can be given, as different species of these insects have different histories. A few general facts, however, will apply to nearly all.

In a general way it may be stated that plant lice pass the winter

in the egg state, and hatch about the time the buds open in the spring. Each is then a tiny insect with six legs and no wings, which crawls about and sucks the sap from the plant on which it is by means of a sharp-pointed beak which it thrusts through the bark or epidermis of the plant till it reaches the sap. In the course of a few days it becomes adult and begins to produce young, giving birth to three or four a day. These young also become adult in a few days and in their turn produce young, and in this way there may be many generations during the summer. Some one or more of these generations will develop wings and pass to the other plants, thus distributing the insects over the region. In the fall some generation instead of giving birth to young, will lay eggs, and these will winter over and hatch the following spring.

Treatment.

As plant lice are sucking insects, no stomach poison such as Paris green or arsenate of lead is of any value to destroy them, and kerosene emulsion is the most effective remedy made use of. In order to kill the lice, however, every insect must be touched by the oil and this requires careful and thorough spraying. As the lice are usually on the under surface of the leaves the spray must be thrown upward against the lice, and after the leaves begin to curl this is very difficult if not impossible. It is necessary, therefore, that the trees should be carefully watched, and be sprayed as soon as the lice appear, and before they have become so abundant as to cause the leaves to begin to curl.

In places where it can be obtained, a strong stream of cold water thrown through a hose upon a tree infested with plant lice, is very effective as it knocks the lice off the tree and kills nearly all of them, but too often this treatment is not available.

In the case of the pea-vine louse, the peas grow in such a way that it is difficult to reach the lice by spraying, and here the best practice is to follow along the rows on a hot day with a branch from some evergreen tree, or a piece of brush, and switch the lice off the vines onto the ground, which can be easily and rapidly done. A cultivator should then follow along the rows and loosening the dry, hot soil, the lice will be dried up by it and die before they are able to return to the plants from which they had been switched off.

SPRAYING MATERIALS.

The chief materials for spraying here suggested are Paris green, arsenate of lead and kerosene emulsion. It is well to speak more fully of these substances as one-half of the value of spraying depends upon whether they are properly made or not, while the other half is determined by when and how they are applied. Combinations of insecticides and fungicides are also important for if these can be applied together rather than separately much time and labor can be saved. A short consideration of these points, therefore, should be of value.

Paris Green.

This insecticide which has been used in quantities for the destruction of insects longer than any other, is a chemical combination of arsenic, copper and acetic acid. The arsenic (arsenious oxide) is of course the poisonous substance, and a good Paris green should contain over fifty per cent. of it. Much that is on the market, however, contains less than this amount, and is known as "Low grade Paris green," and is worth less for use than the higher grades (though it is generally sold at about the same price as the better article), as the farmer who uses it is putting less poison on his crops than he supposes.

In some States, laws have been enacted requiring that all Paris green sold should contain at least fifty per cent. of arsenic—a law that has frequently done more harm than good—and in order to comply with it, manufacturers sometimes produce a low grade article, and during its manufacture or afterwards, add enough arsenic to bring the percentage of this substance up to that required by the law. But the arsenic thus added does not chemically combine with the other substances present in the Paris green, but remains as free arsenic which burns the leaves badly as everyone who has used much Paris green knows. In this way a poor quality of Paris green which would cause little or no burning of the foliage, becomes, by the addition of the free arsenic, a dangerous substance to apply to leaves of any kind.

Another objection to Paris green is that it is frequently adulterated with other substances, such as flour or plaster. Though such adulterations do no harm when applied to foliage, the purchase of such Paris green is much more expensive than it would be to buy these materials separately and mix them.

A further objection to Paris green is that some of the arsenic ac-

tually combined with the copper and acetic acid appears to dissolve in water in the spraying tank, and in this way even a reliable article may sometimes cause burning.

Finally, Paris green when mixed with water is quite heavy and tends to settle to the bottom of the tank, and though all good spray pumps are provided with an automatic agitator, the amount of the poison sent out when the tank is full and when it is nearly empty will differ considerably and the results will be correspondingly unreliable.

For these reasons Paris green is less favorably looked upon as an insecticide than was once the case, and other materials are being more used each year in its place.

Arsenate of Lead.

This substance is a chemical combination of arsenic and lead, and as the arsenic in it is all combined, no burning from its use results, no matter how strong it is made. It is therefore safe to use on all kinds of trees.

It is lighter than Paris green, needing little stirring to keep it from settling, and it adheres to the leaves a much longer time, it generally being necessary to spray but twice with it where three times would be needed with Paris green. Thus, though it costs a little more, this cost is more than an off-set by the reduction in number of treatments necessary.

It is made as follows:

Arsenate of soda (50 per cent. strength),..	4 ounces.
Acetate of lead, ...	11 ounces.
Water, ...	150 gallons.

Put the arsenate of soda in two quarts of water in a wooden pail, and the acetate of lead in four quarts of water in another pail, also of wood. When the chemicals are all dissolved, pour the contents of both pails into the spraying tank with the rest of the water, and stir for a few minutes before using.

Those who prefer to make use of arsenate of lead ready prepared can obtain it from the Bowker Insecticide Company, 43 Chatham street, Boston, Mass., by whom it is sold under the name of Disparene, or from several other firms which supply this article.

Kerosene Emulsion.

Paris green and arsenate of lead are termed stomach poisons, and are used for insects which bite off and swallow solid food. Kerosene emulsion is a contact poison and is used for those insects which suck the juices from plants and which cannot therefore be destroyed by stomach poisons.

Where a contact poison is used it is necessary to touch each insect with a drop of the spray in order to destroy it, while a stomach poison may be spread upon the leaves for the insect to eat with its food at any time it may happen to reach it. Spraying with contact poisons is, therefore, much more difficult than with stomach poisons.

Kerosene emulsion is usually made as follows:

Hard soap, shaved fine,	½ pound.
Water,	1 gallon.
Kerosene,	2 gallons.

Dissolve the soap in the boiling water; remove it from the fire and pour it into the kerosene while hot. Churn this with a hand spray pump until it changes to a creamy, then to a soft butter-like mass. This may be used as a stock, and should keep for some time. For use, take one part of the stock and nine parts of water for plant lice, though where the insects to be treated have harder bodies, one part of the stock to four or five parts of water can be used to advantage.

Insecticides and Fungicides.

It is important to spray fruit trees before they blossom, with Bordeaux mixture to destroy fungous diseases, and as this is also the time to spray for many insects it is often desired to use the insecticide and fungicide together. This can be easily done, the Bordeaux mixture combining well, both with Paris green and arsenate of lead, and the following directions give the best methods for preparing these combined sprays:

Bordeaux Mixture and Paris Green.

Bordeaux mixture,	50 gallons.
Paris green,	4 ounces.

Stir the two till well mixed before using.

Bordeaux Mixture and Arsenate of Lead.

Prepare the arsenate of lead as already directed, but instead of adding the two chemicals when dissolved, to the rest of the water in the spraying tank, add them to fifty gallons of the Bordeaux mixture placed in the tank and stir for a few minutes before using.

THE VARIETIES OF FRUIT THAT CAN BE PROFITABLY GROWN IN PENNSYLVANIA.

By Gabriel Hiester, *Harrisburg, Pa.*

When a man plants an orchard of apples or pears he is starting in a work that will last his life time. If he selects the wrong location for his orchard, or makes a wrong selection of varieties, even though he may give it the best and most intelligent care later on, he will fail to obtain a full measure of profit for his work.

LOCATION.

It is difficult to give accurate directions as to the selection of a location for an orchard or to describe a soil that will bring the best results. There are a few general principles, however, that have become firmly established by the experience of the most careful horticulturists extending back through the past century, and have been fully proven by a number of correspondents who have aided in this investigation. There are several points to be considered in selecting a location which apply to all fruits, and may be briefly stated here as follows:

Soil.—All fruit trees require a *deep* soil on an open sub-soil that will allow perfect drainage. Let me then impress upon the mind of the reader, that the first requisite for the profitable production of fruit of any kind is an *open sub-soil* that will allow perfect drainage; second, a *deep top soil* of a character suited to the kind of fruit grown. The character of soil best suited to each kind of fruit will be treated later on. Stones and boulders are not injurious, but on the contrary, rather a benefit; the loose stones on top serve as a mulch and retain moisture, and the roots find their way around and under the boulders and there secure a good supply of moisture. For this reason many stony hillsides and flat mountain tops which cannot be utilized in any other way furnish excellent sites for orchards.

Exposure.—Opinions differ somewhat on this point, but a majority seem to favor a northern exposure, as the idea prevails that the buds are retarded somewhat, and are less liable to be injured by late frosts. Also that a southwestern exposure is least desirable.

Altitude.—Is more important than exposure. The trees should

be planted above the level of the lake of cold air that settles in the valleys at night; the warmer and more sheltered the valley the more important is this point, as these places are most subject to late frosts. No fixed height can be given at which it will be safe to plant; it will depend upon the width of the valley and the abruptness of the slope at either side. Each planter must decide for himself what will be a safe altitude.

Conditions differ, however, along the shores of lakes and broad rivers; here the water tempers the air and prevents injury by late frosts. We find the influence of Lake Erie extends two or three miles inland, while along the Susquehanna, peaches growing close to the bank frequently escape injury, while the entire crop has been destroyed by frost in an orchard a mile back in the country.

While good fruit can be grown on these bottom lands which border on rivers and lakes, provided they are well drained either naturally or artificially, yet as a rule the fruit will not be as high colored, as fine flavored, nor have as good keeping qualities as that grown on higher ground; this is especially true of the apple.

Rainfall.—The distribution of rainfall throughout the entire season is important. Trees require a large amount of moisture during the growing season to properly mature their crop of fruit. As the summer showers usually follow mountain ranges, the foothills of the mountains and high narrow valleys are generally better watered than the plains.

Shipping Facilities.—After we have grown our fruit we must market it, and here comes in an important item of expense. We should take into consideration, not only the distance of the orchard from the railroad station, but if possible get within reach of competing lines of railroad, and thus secure the lowest possible freight rates.

With these points firmly fixed in our minds we are ready to intelligently consider what to plant.

APPLES.

I. SOIL.

Apple trees will thrive and do well in almost any well drained, well prepared soil. A deep, strong, sandy or gravelly loam with open sub-soil is generally recommended, but the best results have been obtained in this State on soils formed by the breaking down of shale. Good reports come from gray, red and yellow shale lands. Such a

soil is rich in iron, calcium, magnesia, phosphoric acid and potash, with but little nitrogen.

Whatever the other characteristics may be, it should be *deep* to allow extension of the roots; *well drained*, either naturally or artificially, to prevent injury from stagnant water below the surface, and *firm*, and not peaty or spongy, to preclude injury or destruction from frosts. Just here I quote from a letter received from Mr. Edward T. Ingram, of West Chester, a fruit grower of large experience:

"In considering the varieties of fruits to plant, the character of the soil and elevation are the most important points. From my observation I would formulate, on general principles, as follows:

"1st. On heavy soil, retentive of nitrogen, the fruit will be larger, and have more water in its composition.

"2d. That on soils not retentive of nitrogen, but rich in potash, the fruit will be smaller and of higher flavor, with more sugar in composition.

"3d. That varieties of fruit of high flavor are of better quality when fully grown; that large, fine specimens are delicious, while smaller ones are acid and unpleasant.

4th. That varieties of low flavor, when overgrown, are insipid and poor in flavor, but are much better when smaller and with a higher development of sugar.

"5th. That varieties that bloom early or require a longer season for development, will frequently fail at comparatively low altitude and be successful at high ones."

II. VARIETIES.

It is a mistake to plant many varieties. The most successful practice is to select the best of its kind for each season, and have only one, or at most, two varieties of any kind of fruit ripening at the same time.

The first question to consider in this connection is, "Where do we expect to sell our fruit?" We have the world for our market, and excellent facilities for reaching any part of it. The display of fruit at the Paris Exposition has started inquiry in regions heretofore untried, and the limits of the foreign market are being indefinitely extended. So also is the demand for home consumption in the various mining and manufacturing towns all over our own and immediately adjoining States.

The foreign market demands winter apples that keep well, ship well, and stand up for a reasonable time after being taken from cold storage, and seem to prefer red color.

The home market will use a good baking apple at any season of the year. Care should be taken, however, not to plant too many

early ones. Housekeepers begin using them early, and the demand steadily and gradually increases until after the holidays, when it is practically unlimited.

Mr. Geo. T. Powell, in an address delivered recently before the New York State Fruit Growers Association said:

"We need to study the demands of the different markets. London will pay the highest price for red apples of medium size; Liverpool will pay high prices for large apples like King, Twenty Ounce, Hubbardston and Spy. The same is true of our home markets, and to realize the highest value, the shipper must understand what the different markets most demand. Boston will pay the highest price for Fameuse, Gravenstein and McIntosh; New York for King, Jonathan and Rhode Island Greening; Chicago for Hubbardston, and Gillifiower will bring more money than any other variety in the southern cities."

In this connection it may be well to consider the comparative prices obtained in England and Germany during a stated period as a guide to planters of new orchards. We find that during a period of five months the average of price ranged from highest to lowest in the following order:

ENGLAND.	GERMANY.
Jonathan,	Jonathan,
York Imperial,	Northern Spy.
Tompkins King,	York Imperial,
Northern Spy.	Tompkins King,
Spitzenburg,	Baldwin,
Baldwin,	Spitzenburg,
Ben Davis,	Winesap,
Winesap.	Ben Davis.

While it may be best for those having good fruit lands, within easy reach of the main line of railroad, to plant for the foreign market, it will be found equally profitable in most of the southern, central and western counties, to cater to the demands of the home market, hence in this article we will consider varieties suited to both.

In planting an apple orchard, we do not expect to reap our reward for eight or ten years. Hence in the selection of varieties we should ask ourselves the question, "What will the general public think of this apple after an intimate acquaintance of ten years? Will they be likely to ask for it, to insist on having it? or may they possibly tire of it and look for something better suited to their taste?" Those who are familiar with the markets of Pennsylvania know, that in those sections where Summer Rambo and Smokehouse have been grown for some years, about the first of August, housekeepers begin

inquiring for Summer Rambo, and will be satisfied with nothing else while Summer Rambo lasts, and later on they must have Smokehouse or nothing, and there is no use trying to force any thing else on them during the respective seasons of these two varieties.

Reasoning from this standpoint, How will Ben Davis stand ten years hence? Will people be asking for Ben Davis in a market supplied with Newtown Pippin, Baldwin and Northern Spy? We are told that it is in good demand to-day, but will it last when people have become thoroughly acquainted with it? Already buyers have come from St. Paul and Minneapolis to Adams and Franklin counties and bought up whole orchards of York Imperial at a time when their home markets were well stocked with western grown Ben Davis. I think it is a mistake to advocate the promiscuous planting of this variety, but would lay down this positive rule: Never plant Ben Davis where York Imperial will succeed, plant very sparingly of York Imperial in the higher altitudes where Baldwin, Northern Spy and King do well. There are some sections of Adams and Franklin counties where Ben Davis, and its near relative Gano, are grown as fine in form and color as anywhere in the world, and climatic conditions are such in these sections that Baldwin and Spy are fall apples; in such places Ben Davis and Gano are probably the best varieties to plant for profit. As we follow the same range of hills into York, Cumberland and part of Dauphin counties, York Imperial will be found profitable and should gradually replace Ben Davis. Following this same mountain range still farther to the northeast, into Schuylkill county, York Imperial should be gradually replaced by Baldwin and Grime's Golden, and after Schuylkill is passed it should be dropped out of the list altogether.

Up to this time the only apples that have been sent abroad from Pennsylvania, in any quantity, are Ben Davis, Gano and York Imperial. Several large plantations have recently been made along the South Mountain, in Adams county, with the expectation of selling the product in European markets, and in the next few years the number will no doubt be largely augmented.

We have a number of Pennsylvania apples that have been grown for years in their native counties and are much prized where well known because of the vigor of the tree, the regularity with which they bear, and their excellent cooking and keeping qualities.

We will here briefly discuss the merits of a few old, well-tried sorts, and some that seem to be worthy of more general distribution.

SUMMER APPLES (FOR LOCAL MARKET ONLY).

Early Harvest is the standard with which we compare all early sorts, and should be found in every collection. The tree is hardy,

a regular bearer, one of the earliest and best baking apples that we have.

Benninger.—A large, red-striped apple, grown in Lehigh and Montgomery counties, supposed to be a native of Lehigh. It is about as early as Early Harvest. Keeps better and lasts longer. Has been found more profitable than either early Harvest or Red Astrachan. It has been sold in the local markets for more than 40 years. Recommended by Geo. H. Rex & Son. Stetlersville, Lehigh Co.

Red Astrachan.—This apple although of second rate flavor, has been largely planted on account of its very handsome appearance, the vigor and productiveness of the tree and its excellent culinary qualities, and has been found one of the most profitable very early sorts.

Yellow Transparent, is probably one of the best early apples to plant for nearby market. The tree is an early and abundant bearer, and the fruit sells readily on account of its beautiful, clear, smooth appearance and good cooking quality. Its thin skin and light color make it a poor shipper, unless put up in small packages and very carefully handled.

Keswick Codling is an excellent late summer baking apple. It succeeds well in the Cumberland Valley. Tree is hardy and vigorous, a good bearer and the apple sells well. Valuable for home market.

FALL APPLES.

Austin Sweet is one of the very few sweet apples worthy of notice; it is a large, rich flavored, golden, September apple; used for apple-butter, for spicing and preserving; it us used extensively for butter with quinces. Recommended by J. B. Johnston, New Wilmington, Lawrence Co.

Duchess of Oldenburg, while a fall apple in the higher altitudes, is a summer apple in the Susquehanna Valley. The tree is remarkably hardy and vigorous, bears early and abundantly, the fruit is handsome, and while not of the best quality, is excellent for culinary purposes, being very tart ,and is a good seller in any market.

Kretchman is a large, sour, dark red apple, good for cooking or eating in late fall. A good market variety. Recommended by G. H. Rex, Stetlersville, Lehigh county.

Lehigh Greening.—A large, greenish-yellow, fall apple, good for baking; tree is vigorous and hardy, a good bearer. Apple sells well in the markets of Lehigh and Montgomery counties, where it is grown to a considerable extent.

Maiden's Blush.—This beautiful fall apple has been successfully grown in nearly every county of the State and seems to be a general favorite for the home market; the tree is a thrifty, vigorous grower,

and bears regularly and abundantly. The apples sell well in any market on account of their attractive appearance and their good baking qualities.

Summer Rambo is one of the most profitable fall apples that can be grown for the home market in Pennsylvania. Its large size, attractive appearance and excellent quality, either eating or cooking, commend it to every housekeeper, and the man who has them for sale need have no other kind ripening at the same time, as there is nothing in its season that can compare with it. It succeeds well on either high or low land, if the latter is well drained.

Smokehouse follows immediately after Summer Rambo, and is the only fall apple that can take its place. The tree is a rather crooked, scrubby grower in the nursery, but when planted in the orchard and carefully pruned, it grows vigorously, and bears abundantly. It thrives and does well on rich, valley farms, on clay, shale, gravel and loam. In fact it seems to do well on any rich, well drained soil, and it sells at top prices in any market. As its season is about the same as King, there seems to be no reason why it should not be grown in the northern tier of counties for export. It is certainly worthy of trial.

White Doctor.—A native of Pennsylvania, is a very large, green, baking and eating apple, of excellent quality; ripens about the 1st of October. Good for local market.

Tompkins King.—While generally classed as a winter apple, it is a fall apple in most counties of Pennsylvania, but owing to its fine appearance and excellent quality, it sells well at any time. The tree grows vigorously and bears well for a few years, but usually is very short lived. It has been suggested by Prof. Bailey, that this variety should be top worked on some stronger, hardier stock, like Northern Spy, and a number of trees have been treated in this way during the past few years. If the experiment proves successful this will be a very profitable variety to grow either for home market or for export.

WINTER APPLES.

Baldwin stands at the head of the list in popularity. It has been reported as one of the five best varieties by every grower who answered my circular of inquiry. The objection to it in southern Pennsylvania is, that it ripens too soon, and is apt to drop before picking time. This premature dropping, however, is generally caused by leaf blight, which attacks the leaves, and they are unable to perform their functions during the latter part of the season. It has been found, if the trees are thoroughly sprayed three or four times during the season with Bordeaux mixture, that the leaves will

remain healthy, and the apples will remain on the tree until the middle of October, and will keep till mid-winter in an ordinary cellar. It should, however, be planted on moderately high, well-drained ground. When planted on low ground near the water level, even if well drained, the fruit lacks color and keeping qualities.

Baer or Hiester.—A medium sized, red striped apple, grown to some extent in Berks county. It is a heavy bearer and good keeper. A very pleasant eating apple and sells well in local markets.

Belmont or Gate.—A native of Lancaster county. Is a light yellow, early winter apple, of excellent quality; tree is vigorous and healthy and very productive. Apple sells well in the markets of Mercer county, where it has been grown to some extent.

Dominie.—A red striped winter apple of good size and excellent quality. The tree is vigorous and productive, and the apple is a good keeper. It has been grown for some years in York and Cumberland counties with profit, and it seems to have all the qualities needed for export.

Ewalt or Bullock Pippin.—A native of Bedford county; should be more generally planted for the local market. It is a handsome apple, of excellent quality, a good keeper, and the tree is a vigorous grower and a good bearer.

Grime's Golden while a native of Virginia, succeeds well in many counties of Pennsylvania. A leading fruit grower of Blair county says of it. "Grime's Golden is par excellence the apple for Pennsylvania local market; the tree is a slow, compact and spreading grower, and it is a regular, heavy bearer; one of the best early winter varieties." In some places it has proved short lived, like King and Fallawater. It would probably be advisable to top work it on some hardier sort. It does equally well on high or low land, but requires a sandy or gravelly soil; does not do well on clay or limestone.

Greist's Fine Winter.—A native of York county. Yellow-striped, with light red, in shape and size resembling Ben Davis. Tree is a vigorous grower and regular bearer; fruit keeps all winter in an ordinary cellar; is crisp, juicy and of sprightly flavor; has been found quite profitable in Lancaster county, as it does well on a limestone soil; considered worthy of trial for export.

Krauser.—A native of Berks county, where it is held in high esteem. The tree is a vigorous and handsome grower, and an abundant and regular bearer. It is a very good, red apple and keeps well. It has been grown to some extent in Perry county. It sells well in every market where it has been offered, and should be more generally cultivated and should be added to the list of Pennsylvania apples grown for export.

Langford and *Nero* are both long keepers and worthy of trial in

every county of the State. Up to this time they have only been grown in Lehigh county.

Larrer is a large red-striped, sub-acid winter apple; it keeps well and is very productive. It has been found profitable wherever planted in Pennsylvania.

No Name, Spice Seedling and Cumberland Seedling are three local varieties introduced by Longsdorf Brothers. They have done very well in the Cumberland Valley and are considered worthy of trial elsewhere for local market.

Nottingham.—A native of Chester county. Is a large, red, early winter apple, good for eating or baking. Sells readily and is productive. Recommended by J. Hibberd Bartram, who has planted a large orchard of them in Chester county.

Russian Catalet is a large, red apple, grown in Fayette county. Excellent for baking as well as eating; will keep till June. Recommended by L. C. Harris, of Perryopolis.

Rhode Island Greening.—Cannot be recommended for planting in Pennsylvania, except in the northern tier of counties, as in all other parts of the State it ripens its fruit too soon, generally in September and October.

Rambo is a profitable apple for home market. It can be grown on any sandy and gravely soil with a good sub-soil, at almost any elevation, provided the ground is well drained. To secure best results they must be well sprayed. They are not late keepers, and owing to their thin skin and soft flesh are not good shippers, but when marketed in 20 pound baskets, bring the top price.

Ridge Pippin is desirable on account of its keeping qualities, it will keep all winter in an ordinary cellar, and is productive. It is found in many orchards in Montgomery, Bucks and Berks counties, and is a fairly good apple in the spring.

Strinetown Pippin has never been generally disseminated, but has been grown by many farmers in southern and southeastern Pennsylvania, especially in York, Cumberland and Lebanon counties, and has been found profitable when grown on high, rich land. It is an annual bearer, is totally unfit for use in the fall, but when buried in a pit just as turnips are buried, comes out in March clear and crisp, and is one of the best baking apples of the season, far superior to Ben Davis, York Stripe, York Imperial or even Ridge Pippin, which is thought so much of in Chester county.

Stark is a large, red-striped, winter apple of good quality. It is grown to some extent in Franklin, York and Perry counties, and is esteemed for its good keeping qualities. It is productive and profitable, a good shipper; worthy of trial for export.

Stayman's Winesap.—A large, red winter apple. Has been fruited

lately in the Mt. Pocono region and gives promise of great value, on account of its fine appearance and its good keeping and shipping qualities.

Winter Blush—Strongly resembles Maiden's Blush, but is much later. Its season being from December to February.

York Imperial.—Varies greatly both in keeping and eating qualities. When grown on rich, river bottom lands in Dauphin county, it is a very low grade apple and will not keep until the holidays. Under any circumstance it is not good to use in the fall, but when grown under proper conditions, on moderately high land, rich in mineral matter and rather deficient in nitrogen, and is kept in shallow bins in a cool cellar, or better yet, in a cave, it comes out in the spring a fairly good apple for any purpose. It will stand up longer and bear more rough handling than any of the finer sorts, and coming after all the strictly high class varieties are out of the market, it sells well. For this reason the growers of Adams, Franklin, York and Cumberland and some parts of Dauphin and Lebanon counties have found it very profitable. It is not a good cold storage sort, but scalds badly if kept too long. If placed in cold storage it should always be marketed early in January.

Smith's Cider.—A native of Bucks county. Is a mild, sub-acid, red apple. Considered one of the most profitable varieties in Chester, Berks and Bucks counties. It is excellent for baking, a good shipper and a long keeper. It, however, requires a strong soil, and not much elevation. When planted on poor mountain land it is apt to twig blight, and has a general unthrifty appearance.

Red Cider resembles Smith's Cider, but is a better keeper and has more color and is in all respects a better apple.

PEARS.

The market for pears is likely to be greatly enlarged during the next few years. They are in good demand in European markets, when they can be placed there in good condition. The U. S. Department of Agriculture is making careful experiments in the matter of packing and refrigeration, two very important points in ocean transportation. It is hoped that as a result of these experiments, conditions will be so changed that pears will become a common export. Bartlett and Anjou pears have already been shipped to Edinburgh with such cold storage as we have, and sold at a profit, while Duchess have arrived in good condition without cold storage. We need not be afraid of planting too many pears at this time; before the trees

come in bearing the foreign market will be ready for them and proper facilities for transportation will have been arranged. The Paris Exposition did much towards introducing American fruit to foreign nations, and our Government is doing what it can to make it possible for us to take advantage of the demand thus created. The Canadian Government is experimenting along the same line, and the Canadian growers are eager to take advantage of any improvement in conditions. If Pennsylvania wants a share of this trade we should begin to plant at once.

VARIETIES.

Out of the great number of pears that have been tried at various times in this State, there seems to be only five that have stood the test of time and can be recommended as profitable market sorts, namely, Bartlett, Seckel, Duchesse d'Augouleme, Lawrence and Kieffer. We need a better early sort than Clapp's Favorite for the home market, as it blights badly in many places and cannot be recommended for general planting. Catherine and Manning's Elizabeth are prolific and of fairly good quality, but too small; the same objection holds as to Tyson and Bloodgood. Here is a field for the experimenter.

Bartlett is the only pear that received a double star from every correspondent. It stands at the head of the list as a profitable market sort, and although some persons object to the flavor, it is the best seller in every market. The tree is less subject to blight than any other variety. It is a regular, heavy bearer and good shipper. It does well either as standard or dwarf. Pennsylvania Bartlett and Seckel pears have a place of their own in the home markets. They ripen a couple of weeks before those grown in New York, and so for a short time they have the market all to themselves, and if these two varieties are offered as soon as they mature they always bring a fair price and will yield more clear profit at that time than at any later period. They will do well on a clay soil too heavy for apples and can be grown on any deep, well drained soil, on mountain or valley, and will yield regular profitable crops.

Duchesse d'Augouleme is one of the best market sorts, and is remarkably healthy in tree and foliage. It is usually grown as a dwarf but will succeed admirably as a standard. The fruit is large and handsome, has a thick skin, is a good keeper, a good shipper, sells well in all markets, and when properly ripened, is an excellent pear.

Howell is an excellent canning pear, very fine grained and white fleshed. A good shipper, if well grown and picked at exactly the right time, but it is subject to blight in most places. The fruit is also subject to scab, and in order to secure good fruit, the trees must be thoroughly sprayed several times during the season.

Bosc.—Is a luscious table pear of beautiful appearance, bears

early and regularly if planted on rather high ground in fairly fertile soil, with an open sub soil, protected from piercing north winds, well cultivated and regularly sprayed to protect it from fungus and insect pests. It is a poor grower and, therefore, must be top-worked on some strong growing sort. It does admirably on the foothills of the Alleghenies, in Blair county, but on the rich bottom lands of the Susquehanna the pears are knotty and the trees subject to leaf blight.

Lawrence is classed as a winter pear, and when grown on the higher altitudes may be kept all winter in an ordinary cellar, the same as apples are kept. It is very sweet and one of the best desert pears. The tree is a strong, vigorous grower and an abundant bearer. It is a good shipper, and when well grown and properly ripened always commands the highest price.

Flemish Beauty, like the Bose, succeeds best on the foothills and elevated small valleys. It is a beautiful pear, a good shipper, of excellent quality, but must be picked just before maturity. It does not succeed well in the Susquehanna Valley on account of leaf blight, which causes the foliage to fall off before the fruit is full grown, unless the trees are carefully sprayed several times during the season.

Pitmarsden Dutchesse has been tried in Blair county and has done well. The tree is a fairly good, upright, grower and an enormous bearer of large fruit, ripening somewhat earlier than Duchesse d'Augouleme, which it much resembles.

Madam Seibold is a seedling of some good pear and Chinese sand pear. The fruit resembles in color a golden russet apple when fully ripe. It has a bright, golden color, it keeps well and sells well in the markets of the western part of the State. It has only been grown to any extent in Blair county.

Kieffer.—The much advertised, much abused Kieffer also has its place. It is an excellent canning pear, and may be grown with profit in the neighborhood of a canning factory, but the general market is very easily overstocked with them, and unless there is a canning factory within easy reach, they should be very sparingly planted.

Koonce is a large pear, a regular bearer, quite prolific. Is grown to some extent in Westmoreland county and found to be a profitable market variety.

PEACHES.

While peaches can be grown in every county of the State, it is not advisable to plant commercial orchards in regions much subject to

severe winters or late spring frosts. In districts where the thermometer frequently falls lower than 15 degrees below zero the crop will prove very uncertain. It is best to select a climate not given to extremes of any sort, and one which has a considerable rainfall, fairly well distributed throughout the year; for this reason the foothills of mountain ranges and high, narrow valleys, are desirable for reasons that have been previously stated. Some fields on a farm may be much better for peaches than others; high lands are generally better than low lands; rolling land is better than flat; a water front on a lake or broad river is better than an inland location. In inland regions a hillside with a northern exposure is generally preferred. When planting on a hillside care must be taken to keep above the frost line.

Soil.—The peach does not seem to be particular as to soil, but will succeed on any well drained land with a good sub-soil; the preference in this State appears to be for a sandy loam, filled with broken stone, from which chestnut timber has been removed. In York and Cumberland counties, what are known as the iron stone soils have given the best results.

One very important point in the selection of location for a peach orchard has been overlooked by many Pennsylvania growers to their sorrow, namely, a *deep soil.* No matter how favorable are the other conditions, without a deep, well drained soil and a good sub-soil, no one may hope for a full measure of success, as the ripening crop needs a large amount of moisture and this cannot be obtained from a thin soil.

Easy Access to Market is an important point. The crop ripens rapidly and must be disposed of quickly, therefore it is essential that the orchard should be within easy reach of a railroad station, and if two competing lines of road can be reached an advantage in freight rates may be secured. This is more important with peaches than any other fruit crop. Pennsylvania is well supplied with good markets in its hundreds of mining and manufacturing towns, and most of her fertile valleys are intersected by railroads, so that good locations may be had in almost any part of the State within an hours drive of the station.

Varieties.—In the selection of varieties we must consider our market. Peaches must be sold direct from the tree, and can be held only for a very short time, hence to secure profitable prices we must have our peaches to ripen when our markets are not well supplied from other States. This necessitates the discarding of all varieties that ripen earlier than Elberta. The glut of southern peaches is over by the time Elberta is ripe, and then for about three weeks we have a comparatively clear field to operate in. Yellow fleshed

peaches are in better demand all through the season than white fleshed and usually command a higher price. The following are a few of the most popular varieties, with some criticisms, that have been made on them by correspondents:

Chair's Choice, pronounced good in Franklin county.

Salway does not succeed well everywhere. It should be planted on a gravel soil with good sub-soil, should have considerable elevation, north or western exposure. It will not do on strong land containing a large amount of nitrogen ,or on clay land.

A correspondent from Franklin county writes: "Bilyeus and Edgemont Beauty are the money makers."

Pride of Kennett, a medium late white peach, introduced by Rakestraw & Pyle, is a native of Chester county. It has an exceptionally fine flavor and beautiful color, but must be severely thinned, as it has a tendency to overbear, and on low ground in wet seasons will crack and mildew. It is a splendid peach for high ground that is rich and deep.

Cumberland county claims two seedlings of merit, known as Seedling White and Seedling Yellow. They can only be found in the local nurseries.

Fox Seedling, Ohio Beauty and Reeve's Favorite are highly recommended for Cumberland county.

Early Rivers, Hill's Chile, St. Johns, Lewis and Kalamazoo are favorites in Erie county. Elberta has proven tender in Erie county.

In Mercer county, A. B. Greenlee of New Lebanon recommends a native peach that reproduces itself from the seed. It is yellow fleshed and of excellent quality. It is quite extensively grown in the neighborhood of New Lebanon.

Iron Mountain has been found to be very productive and profitable in Schuylkill county. Mr. W. H. Stout, of Pinegrove, has grown record-breaking crops of this variety.

In the Susquehanna Valley, Crawford's Late, Elberta, Globe and Red Cheeked Melocoton are the favorite yellow, and Old Mixon, Stump and Fox Seedling the favorite white varieties.

GRAPES.

For many years the grape industry in Pennsylvania has been confined to what is known as the Lake Erie grape belt. A narrow strip along the shore of Lake Erie in this State, and extending some distance into the State of New York, being about forty miles long. The idea prevailed that the crop was surer and the quality of the grapes

better. This may have been true when such varieties as Iona, Diana, Catawba and Isabella were the leading market sorts; but since the introduction of Concord, Niagara, Moore's Early and Moore's Diamond, it has been found that just as good grapes can be grown in the Susquehanna Valley and along the foothills of the Alleghenies and Blue Ridge as can be grown anywhere. At the same time, insect pests and fungus diseases are becoming very troublesome in the Erie grape belt and growers there find that they are obliged to resort to the same methods for protection that have been found necessary in other places. So it would seem that this industry may now be extended to many other parts of the State, with equal profit.

Varieties.—The number of varieties of grapes found in our markets has been much reduced within the past few years. The leading varieties in all commercial vineyards are: Concord, Niagara, Moore's Early, Delaware and Moore's Diamond.

PLUMS.

The general market is easily overstocked with plums. No one should make a large plantation of this fruit unless he has easy access to a canning factory. A reasonable amount can be sold in the city markets at profitable prices, but the canning and preserving factories must be depended upon to take the bulk of the crop. The industry is in its infancy in Pennsylvania. A few large orchards of Japan plums have been planted, but it is too soon to state results. Some of our commission men think the Japan plums will grow in favor with the people. Others say their market does not want them. This is notably the case with Pittsburg.

What is known as the York State Prune, has been grown with profit in Lackawanna county for the local markets.

Yellow Gage, a native of Westmoreland county, is a medium sized yellow freestone of excellent flavor. A good and regular bearer; is propagated by sprouts from the roots; it sells better in the local markets than any other. Recommended by Wm. F. Barclay, of Mt. Pleasant Mills, Pa.

CHERRIES.

The sweet cherries have proven a very uncertain crop. It is easy to grow trees; they thrive on soils that are too thin and dry for any other fruit and seem to do better without cultivation than with it;

but favorable weather, just when the fruit is maturing, is absolutely necessary. A couple days of rain when the fruit is ready to pick, followed by hot sun, may cause the fruit to rot and render the whole crop unmarketable. Robins and catbirds are very fond of them, and destroy large quantities before they are ripe. We would, therefore, advise against the extensive planting of sweet cherries in Pennsylvania, as we usually have thunder storms in June followed by hot sunshine, and our farms should be well stocked with robins and catbirds. It is different with sour cherries. They are not so much affected by rain, especially the later kinds, and the birds do not molest them. Land that is too thin and dry to grow other fruit, or even to grow good farm crops may be profitably utilized by planting to sour cherries, and the general market has never been overstocked with them.

Book Cherry, a local Lancaster county variety, is dark red, ripens about the middle of June, it is medium to large, of fine flavor, a heavy, regular bearer, good shipper, hangs long on the tree before it declines; a very profitable market sort. Recommended by John Weitzel, of Bethesda, Lancaster county.

CLIMATE.

"The climate of Pennsylvania is remarkable for the great change it exhibits between the summer heat of the central and southern portion, and the extreme cold of the uplands of the northern counties. The summer heats are more than tropical both on the Ohio river in the southwest, and the Susquehanna and Delaware in the southeast. While on the highlands of the northeastern counties and in Elk, McKean and other counties of that elevated plateau in which the Allegheny river takes its rise, the winters are sometimes of almost arctic severity. The difference in elevation is the chief cause of the low temperature on the northern plateaus; their average being about 1,500 feet above sea level, in some cases, large tracts reach nearly 2,000 feet, still being generally level enough for cultivation. The Susquehanna Valley cuts deeply through the whole mass, and along the main stem and principal branches it affords a mild climate and prolific soil, admirably adapted to the production of fruit. Tornadoes and hurricanes, such as are known on the Atlantic Coast, from the Gulf of Mexico to New England, are never experienced within the limits of the State in any marked degree of severity.

"Altogether, Pennsylvania has a climate highly favored in many

respects, usually dry, clear, elastic and invigorating. Just what is needed to produce fruit perfect in form, with high color and exquisite flavor."

SECTIONS FOR THE SELECTION OF VARIETIES.

We have divided the State into seven sections or regions, designated on the map and the accompanying tables by the numerals 1, 2, 3, 4, 5, 6, 7, and in the list of fruits have marked each variety as it has been reported from each section; if fairly successful, with a single star, if especially recommended with a double star, in the column bearing the number of that section.

While our classification may not fit every farm in each section, we believe that this, together with the discussion already had on the several leading varieties of fruit, will be near enough for all practical purposes, and is probably as nearly accurate as we can get with our present limited experience in commercial fruit culture.

No. 1. The Southern Region.—The great Cumberland Valley lying between the Blue or North Mountain, and the irregular chain of the South Mountain, taking in the south slope of the North Mountain, and all sides of the York Hills and the South Mountain as they extend in a southwesterly direction through the counties of Cumberland, York, Adams and Franklin to the Maryland line.

No. 2. Southwestern Region.—Following the Susquehanna River from Harrisburg to the Maryland line. The Schuylkill river from Allentown to its mouth. The Delaware River from Easton to the Delaware line. Including the counties of Delaware, Chester, Montgomery, Bucks, Berks, Northampton, southern half of Lehigh, Lebanon, Lancaster and the southern half of Dauphin.

No. 3. Northeastern Region.—The distinguishing feature of which is an elevated mountain plateau 1,200 to 1,600 feet above sea level, extending from Wayne and Pike counties southward into the counties of Luzerne and Schuylkill. This plateau in its broadest part bears the name of Pocono, and seems to be well adapted to the production of winter apples and pears of high quality. It comprises the eastern half of Bradford county, all of Susquehanna, Wayne, Pike, Luzerne, Monroe, Columbia, Montour, Northumberland, Carbon, Schuylkill and upper Dauphin.

No. 4. Northern Region.—Embracing the counties of Warren, McKean, Potter, Tioga, part of Bradford, Wyoming, Sullivan, Lycoming, Clinton, Cameron, Elk and Forest. This region has not yet been developed along the line of fruit production, but seems to possess all the requirements for the growth of apples of high flavor and good keeping and shipping qualities. In the opinion of the writer no better place can be found to grow winter apples than the rocky foothills of the mountains in this region.

No. 5. The Middle Region.—Traversed throughout from N. E. to S. W. by long, steep, rocky mountain ranges, which run in a general way parallel to the main ridge of the Alleghenies. The mountains are not high, the valleys as a rule are narrow, and get narrower as they leave the Susquehanna river. Peaches of the finest quality can be grown along the foothills of these mountains, and the failures that have been reported can nearly all be traced to the selection of hilltops having a thin, shaly soil, that could not furnish sufficient moisture for the ripening crop. Wherever peaches have been planted in deep soil, above the fog line, which is also the killing frost line, they have proved most profitable. In this we have the counties of Union, Centre , Snyder, Blair, Huntingdon, Mifflin, Juniata, Perry, Bedford and Fulton.

No. 6. Western Region.—All that portion west of the Alleghenies drained by the tributaries of the Ohio, comprising the counties of Mercer, Venango, Lawrence, Butler, Clarion, Jefferson, Beaver, Armstrong, Indiana, Allegheny, Westmoreland, Cambria, Washington, Fayette, Greene and Somerset. This is naturally a good fruit district, but wherever coke ovens have been put in operation the fumes have been carried in the air for a considerable distance, and caused more or less discoloration of the fruit. For this reason we would not advise the planting of a large commercial orchard on land underlaid with a considerable body of bituminous coal.

No. 7. The Lake Shore Region.—Comprising Erie and the greater part of Crawford county. A singularly fine and temperate climate characterizes the shore of Lake Erie and completely controls a belt some 15 or 20 miles in width, known as the grape belt, while further inland, even 50 miles from the lake, this influence is sensibly felt.

APPLES.

One Star (*) Fairly Successful. Two Stars (**) Highly Recommended.	1.	2.	3.	4.	5.	6.	7.
Austin Sweet,						**	
Baldwin,	**	**	**	**	**	**	**
Ben Davis,	**	*	*	*	*	*	
Benjamin's Rambo,		**					
Baer or Hiester,		**					
Early Harvest,	**	*	**	**	**	**	**
Escpus Spitzenburg,		*	*	**	*	*	*
Ewalt,		**		*			
Fallawater,		**			**	**	
Fall Pippin,	*	*	**	**	*	*	
Golden Russet,	*	*	**	**	*	*	**
Gilliflower,		**				*	
Gravenstine,	*	*	**	*	**	*	**
Grime's Golden,	**	**	*		**	**	
Gano,	**						
Krauser,	**				**		
Kircher's Kitchen,		**					
Kretchman,		**					
Keswick Codling,	**			*			
Jonathan,	*	**	**		*		
Lehigh Greening,		**					
Lambach,			**				
Langford's Seedling,	**	*					
Maiden's Blush,	*	**	**	**	**	**	
Mother,	*	**			*		
No Name Seedling,	**						
Northern Spy,		**	**	**		**	**
Primate,				**			
Rambo,	*	**	*	*	**	**	*
Red Astrachan,	*	**	**	*	**	**	*
Ridge Pippin,		**					
Rhode Island Greening,			**	**		**	*
Rome Beauty,	*	*	*		*	*	**
Roxbury Russet,			**		**		
Smokehouse,	**	**	**			*	
Smith's Cider,	**	**	*	**	**		
Stayman's Winesap,			**				
Stark,	**		**				
Sutton's Beauty,	**						
Spice Seedling,	**						
Tolman's Sweet,	*		**	**	*	*	*
Tompkin's King,	*	*	*	**	**	*	*
Twenty Ounce,	**	*	*	**	**	*	**
Wagner,		**		*	*		
White Doctor,		**					
Winesap,	*	**	**	*	**	**	
Yellow Belleflower,	*	*	*	**	*	*	
Yellow Transparent,	**	**	**	*	**	*	
York Imperial,	**	**	**	*	**	*	*
York Stripe,	**	*		*	*		

PEARS.

One Star (*) Fairly Successful. Two Stars (**) Highly Recommended.	1.	2.	3.	4.	5.	6.	7.
Augouleme, Duchesse d',	*	**	*	**	**	**	*
Anjou,	*	*		**	*	*	**
Admiral Farragut,	**						
Bartlett,	**	**	**	**	**	**	**
Clairgeau,	*		**		**		*
Clapp's Favorite,	**	*	**	*		*	*
Flemish Beauty,							
Howell,			**	**			*
Kieffer,	*	**		*	**	*	
Lawrence,	**	**	**	**	**		**
Louise Bonne d' Jersey,	*	**	*		*		
Seckel,	**	**	**	*	**	**	**
Sheldon,	**	*	*	*	**	*	*
Tyson,	*	**	*		**	*	**
Winter Nellis,	**						
Washington,	**						
Koonce,						**	

PEACHES.

One Star (*) Fairly Successful. Two Stars (**) Highly Recommended.	1.	2.	3.	4.	5.	6.	7.
Alexander,	....	....	....	....	....	**	....
Beer's Smock,	**	*	....	....	**	**	**
Chair's Choice,	*	**	....	*	....	*	....
Champion,	....	....	**	*	....	**	**
Crosby,	*	**	*	*	*	**	**
Early Crawford,	**	**	**	**	*	**	*
Elberta,	**	**	**	**	**	**	*
Early Rivers,	....	....	....	....	....	....	**
Foster,	....	*	**	*	....	*	....
Ford's Late,	....	*	....	....	*	....	....
Fox Seedling,	**	**	....	....	*	....	....
Globe,	*	**	*	*	**	*	....
Gibson,	**	....	....	....	....	....	....
Iron Mountain,	....	....	**	....	....	....	....
Late Crawford,	**	**	**	*	**	**	*
Lewis Kalamazoo,	....	....	....	....	....	....	*
Lovett's Late,	....	*	....	....	....	....	*
McAllister,	**	....	....	....	....	....	....
Mountain Rose,	**	**	*	*	**	**	*
Old Mixon Free,	**	**	**	**	**	**	....
Reeve's Favorite,	**	**	....	*	*	*	....
Smock,	*	*	....	*	*	*	....
Stephen's Rareripe,	....	....	....	....	....	....	....
Stump,	....	....	**	*	**	*	*
Salway,	**	....	....	*	....	*	....
Susquehanna,	*	**	....	*	**	*	....
Seedling, White (Londsdorf),	**	....	....	....	....	....	....
Seedling, Yellow (Longsdorf),	**	....	....	....	....	....	....
Schaffer,	....	*	....	....	....	....	....
St. John,	....	....	....	....	....	....	*
Wheatland,	....	*	....	....	....	....	*
Ward's Late,	....	*	....	....	*	....	....
Wonderful,	....	....	....	....	*	*	....
Yocob,	....	*	....	....	....	....	....

GRAPES.

One Star (*) Fairly Successful. Two Stars (**) Highly Recommended.	1.	2.	3.	4.	5.	6.	7.
Brighton,	**	**	*	**	*	*	....
Campbell's Early,	....	....	*	**	....	....	....
Concord,	**	**	**	**	**	**	**
Delaware,	*	**	**	**	*	**	**
Diamond, Moore's,	*	**	*	**	**	*	*
Eaton,	....	....	....	**	....	....	....
Herbert,	**	....	....	....	....	....	....
Lindley,	**	....	....	*	*	....	*
Moore's Early,	*	**	*	....	**	**	**
Niagara,	**	**	*	**	**	**	**
Salem,	*	....	**	....	....	*	*
Vergannes,	....	**	....	....	....	....	....
Winchell (Green Mountain),	*	....	**	....	....	*	....
Worden,	*	**	**	....	**	*	**

CHERRY.

One Star (*) Fairly Successful. Two Stars (**) Highly Recommended.	1.	2.	3.	4.	5.	6.	7.
Black Eagle,	**	*	....	*	....	....	....
Book,	....	**	....	....	....	....	....
Conestoga,	....	**	....	....	....	....	....
Cumberland Triumph,	**	....	....	....	....	....	....
Coe's Transparent,	**	*	....	*	....	....	....
Carnation,	*	....	....	....	....	....	....
Early Purple Guigne,	....	**	....	*	....	....	....
Elton,	*	*	....	*	....	....	....
Florence (Mt. Pocono),	....	....	**	....	....	....	....
Great Biggareau,	....	....	....	....	....	**	....
Ida,	**	....	*	....	....	....	....
Louis Philip,	....	....	**	....	....	....	....
Napoleon,	**	**	**	**	**	....	....
Ox Heart,	....	....	....	**	**	....	....
Red Jacket,	....	*	....	....	....	**	....
Spanish Yellow,	*	*	*	**	**	....	**
Tartarian, Black,	**	**	**	**	**	**	....
Windsor,	*	*	*	**	....	*	**
Wood, Governor,	**	*	**	**	**	*	*
Dukes and Morellos.							
Late Kentish,	....	**	*	....	....	....	....
Reine Hortense,	*	*	....	....	....	....	....
May Duke,	....	**	*	*	**	**	*
Montmorency, Large,	....	**	*	**	*	*	**
Montmorency, Ordinary,	**	*	*	**	**	**	**
Morello, English,	**	*	*	....	**	**	**
Richmond,	**	**	**	**	**	**	**
Dyehouse,	....	....	....	**	....	....	....

PLUM.

One Star (*) Fairly Successful. Two Stars (**) Highly Recommended.	1.	2.	3.	4.	5	6.	7.
Bovay (Bovay Green Gage),	**	**	....	*	**	**	*
Bradshaw,	**	*	....	*	....	*	**
Damson,	....	....	....	....	*	**	....
Duane Purple,	*	....	....	....	....	**	....
Englebert,	*	**	*	*	**	....	....
Golden Drop, Coe's,	*	**	*	*	*	....	....
German Prune,	**	**	**	**	**	**	**
Imperial Gage,	**	*	*	*	*	*	*
Jefferson,	**	*	....	....	*	....	....
Lombard,	*	**	*	**	*	*	**
Prince Yellow,	....	....	**	*	*	*	....
Shipper's Pride,	**	....	....	....	....	....	....
Simpson,	....	....	....	....	**	....	....
Shropshire,	*	*	....	*	....	**	**
Washington,	*	*	*	....	**	....	**
Wild Goose,	....	**	**	*	**	**	....
York State Prune,	....	....	....	**	....	....	....
Yellow Gage (Westmoreland Co.),	....	....	....	....	....	**	....
Japan.							
Abundance,	**	**	**	**	**	**	**
Botan,	*	*	**	*	....	....	**
Burbank,	*	**	**	**	**	*	**
Red June,	**	....	**	*	....	....	**
Satsuma,	*	*	**	*	....	*	*
Wickson,	**	....	**	....	....	....	....
Willard,	....	*	....	*	....	*	**

THE STATE BY COUNTIES.

ADAMS COUNTY.

Considerable attention has been paid to commercial fruit culture in Adams county. The land is very much broken by irregular mountain ranges and spurs, which render ordinary farming difficult, but which furnish many excellent sites for orchards. The soil being strongly impregnated with iron, produces fruit of high color and attractive appearance. Here the Ben Davis, York Imperial and Gano apples are grown to perfection and with much profit, and all the mid-season and late peaches do well. Many new orchards of both apples and peaches are being planted this season, and altogether, the fruit industry seems to be in a more flourishing condition than in any other county of the State.

ALLEGHENY COUNTY.

With the exception of winter apples, very little fruit has been grown for market, but with proper care in selecting location for orchards, just as good fruit can be grown here as elsewhere. Peaches and plums are uncertain, owing to late frosts, and severe winters; where they have been planted at the proper altitude, however, they have succeeded very well. There is such an excellent home market for fruit of all kinds, that a special effort should be made to produce it.

ARMSTRONG COUNTY.

The climate is not subject to extremes of temperature, as the north winds coming from the lakes are somewhat modified; the high altitudes afford good locations for fruit growing. The soil on the elevations is generally of a sandy character, and is usually underlaid with a deep clay. Good home markets are afforded by the many new industries that are springing up. Little attention has been paid to commercial orcharding, but fruit of all kind is grown for home consumption.

BEAVER COUNTY.

All kinds of fruit do well if properly cared for, but up to this time it has not been grown as a special crop in a commercial way. Cher-

ries and plums do well when planted on soil suited to them. More attention is paid to apples than to other fruit. Benoni and Keswick Codling have been quite profitable. They are both medium early sorts and sell well because they are good for cooking purposes. Red Stark has also been mentioned as a very profitable sort.

BEDFORD COUNTY.

Owing to the mild climate Baldwin apples drop badly. York Imperial and Ben Davis do fairly well. A red winter apple of good quality is needed. Growers are trying Jonathan, Salome, Stark and Willow Twig. The quality of the latter is so poor that it should be dropped. Cooper's Market seems to promise well. Peaches and pears should be grown with profit.

BERKS COUNTY.

Berks county has had a very active agricultural society for many years, and the annual exhibitions of fruit have stimulated this industry very much. Considerable attention has been paid to the development and propagation of local seedling apples, a number of which have proven quite profitable. Benjamin's Rambo is large, slightly acid, a good baker, one of the best sellers in the local market. Is good from the middle of September until spring and keeps in an ordinary cellar.

Miller, Baer or Hiester, Belmont or Gate, and Yocob, are good keepers and do well. Krauser is one of the most profitable here as elsewhere.

Prince Engelbert plum has been successfully grown in a number of places.

BLAIR COUNTY.

The elevated regions are good for fruit, especially apples and pears. Peaches can be grown, if planted above the fog line. Cherries and grapes also do well, but very little attention has been paid to fruit, only two or three commercial orchards are to be found in the county.

BRADFORD COUNTY.

Bradford is a dairy county, but some attention has been paid to fruit of late years. Baldwin apple leads as a profitable market sort.

Northern Spy, R. I. Greening, Duchesse of Oldenburg and Yellow Transparent do well. Wagner sells well. The tree is an early and prolific bearer, but is apt to be short lived. Peaches and plums can be grown above the fog line. In the Susquehanna Valley we find Concord, Worden, Moore's Early, Brighton, Delaware and Niagara

grapes flourishing. With proper attention to this industry, Bradford can make as good a reputation for fruit as she has already made for her dairy products.

BUCKS COUNTY.

The red shale lands of Bucks county produce good fruit, especially apples. Ridge pippin seems to be the favorite, as it is a good keeper and a good seller. Smith's Cider is quite extensively grown and also Red Cider, which closely resembles Smith's, but has more color, keeps better and seems to be a better apple.

BUTLER COUNTY.

Very little attention has been paid to fruit for market, but the red shale land which is found in many parts of the county always grows good fruit when the soil is deep enough for trees.

CAMBRIA COUNTY.

Is well adapted to fruit culture, although little attention has been paid to it. The soil and climate are quite uniform. Plums, pears, peaches and grapes have not been grown to any great extent, but are being planted and promise well.

CAMERON COUNTY.

Is as yet undeveloped, but when planted for home use, apples, peaches, pears and plums have done well.

CARBON COUNTY.

Is undeveloped, but newly planted orchards that are properly cared for are doing well.

CENTRE COUNTY.

Apples do well, and as there is a good nearby market in the various mining towns, a full line can be grown from the earliest to latest. All sorts of plums do well. Peaches are uncertain on account of late frosts. Cherries do not succeed in the lowest parts of the valleys, but on the hills, and along the base of the Bald Eagle and Allegheny mountains they do well and are profitable.

CHESTER COUNTY.

Here we find a great variety of soil, and constantly varying local conditions. The surface is very much broken. A certain variety of fruit will sometimes do well on one side of a low ridge, while on the other side it fails entirely. Although several of the oldest and most successful nurseries in the United States are located in the county, very little fruit is grown for market. A number of correspondents

express the idea that Chester county is not adapted to fruit growing. In the opinion of the writer, however, this is not the case. Much of the soil is strongly misaceous, furnishing an inexhaustible supply of potash. If such a soil is thoroughly drained and has the proper altitude it should produce good fruit. We have no record of success with plums. Apples succeed when planted in the right place. Smith's Cider for winter and Doctor for earlier in the season, seem to lead. Several local varieties have been quite profitable and are recommended for trial elsewhere. Mother is a very pleasant, sub-acid, red, fall apple, one of the best for use during September and October.

Nottingham is a very good early winter sort, fair size, red color, rather tart, a good baker and good for eating. Tree vigorous, an early and prolific bearer. Recommended by J. Hibberd Bartram who has planted a large orchard of them. Above All and Laurel Pippin are two excellent winter sorts; both are high flavored, of fair size and good keepers. Recommended as worthy of trial by Franklin G. Brooke, of Pottstown.

CLARION COUNTY.

Little attention is paid to fruit growing, except for home use. All kinds of apples do well. European plums rot; Japan plums promise well. North and northeast exposures are preferred for fruit, as buds are apt to be killed by late frosts.

CLEARFIELD COUNTY.

Fruit industry is undeveloped. Apples, peaches, pears and plums promise well where they have been planted and are being cared for.

CLINTON COUNTY.

Apples are the principal fruit grown. Along the foothills of the mountains some fine crops of Smokehouse, Baldwin, Northern Spy, Fallawater and Rambo are raised. A few flourishing peach orchards are reported in which Elberta, Crawford's Early, Mountain Rose, Crawford's Late, Stump and Old Mixon are found. The leading pears are Clapp's Favorite, Bartlett, Seckel and Anjou. Little attention has been paid to plums or cherries, and quinces are only grown for home use. It would seem from the reports received that many parts of the county are admirably adapted to certain kinds of fruit, but the farmers have never given the subject much thought.

COLUMBIA COUNTY.

All parts of the county are not adapted to orchard culture. The fruit grown on the hills is not only finer than that grown in the valleys, but the crop is more certain. Peaches bear in the valley about two years out of five, while on hills 500 feet above the valley they bear four years out of five. The hills generally have a yellow gravel sub-soil. The leading apples are Baldwin, Fallawater and Maiden's Blush; Smith's Cider and York Imperial are being planted, with good prospects of success. Laubach (local), a red sweet apple, is grown in different parts of the county for eating and for cider. It is a regular bearer, hangs well on the tree; keeps in an ordinary cellar all winter. Our correspondent reports that "Cider can be made very late from this variety fit to set before a temperance man or a preacher."

The peaches grown successfully in the hill orchards are Alexander, Early and Late Crawford, Elberta, Mt. Rose, Stephen's Rareripe, Stump and Smock. Pears: Duchesse, Bartlett, Clapp's, Sheldon and Kieffer. Plums, cherries and grapes are only grown for home use. The following varieties are giving satisfaction when planted in yards and gardens: Plums—German Prune, Lombard, Abundance, Satusma. Cherries—Spanish Yellow, Black Tartarian, Governor Wood, May Duke, Richmond. Grapes—Concord, Niagara, Brighton and Catawba.

CRAWFORD COUNTY.

Little attention is paid to fruit outside of the portion known as the grape belt, lying nearest the lake. The farmers of the county are principally engaged in stock raising and dairying. For some years grapes have been the leading fruit grown. Of late years, however, the black rot has attacked the vineyards, and many large plantations have been dug out. Many growers are using Bordeaux mixture on their vines with the hope of saving them, and some with very good success. A few small orchards planted from 150 to 300 feet above the level of Lake Erie are producing profitable crops of apples, peaches, pears and plums. The varieties are: Apples—Baldwin, Golden Russet, Gilliflower, Maiden's Blush and Rhode Island Greening. Peaches—Late Crawford, Champion and Elberta. Pears—Bartlett, Clapp's Favorite, Kieffer. Cherries—Gov. Wood, Black Eagle, Ox Heart, Black Tartarian. The leading grapes here as elsewhere in the State are Concord, Niagara, Delaware and Moore's Early.

CUMBERLAND COUNTY.

All kinds of fruit do well, especially along the slopes of the North Mountain and also the South Mountain or York Hills. European plums and cherries, both sweet and sour succeed very well. All of

the Japan plums have been tried in some parts of the county with very good success, being near market the early pears, such as Bloodgood, Catharine, Clapp's and Tyson are profitable. It has been found that the elevated ground along the foothills of the mountain, grow the best peaches, and the surest crops year after year. Varieties of fruit are selected with a view to their market value. As all kinds seem to succeed if properly cared for, small fruits of all kinds, but especially strawberries, are grown in large quantities and find ready sale in the Harrisburg, Carlisle, and Mechanicsburg markets. These are the three principal shipping points for the county. While the soil in the valley is principally limestone clay, on the hills we find a variety of sand, loam, shale and flint soil, all of which are well suited to fruit culture.

DAUPHIN COUNTY

Contains a great deal of good fruit land along the banks of the Susquehanna and on the elevated portions of all the valleys running back from the river. The climate is mild, however, and apples ripen early. Northern Spy ripens and must be sold in October. Baldwin is in prime condition just before the holidays, York Imperial, Grime's Golden and Strinetown Pippin have been successfully grown, and are profitable winter sorts, when planted on moderately high land, with deep open sub-soil. Peaches, pears, grapes and cherries flourish, if planted on proper locations and judiciously cared for. Small fruits have been grown in considerable quantities, but the industry has not been as profitable of late as formerly, and in consequence, the size of the plantations has been considerably reduced.

DELAWARE COUNTY.

Little attention has been paid to fruit culture for market. Although all kinds of fruit do well if properly cared for, as is shown by the character of fruit grown in the small orchards planted for home use. Conestoga Seedling Cherry and Cumberland Seedling have been found profitable. The Pyle apple originated and is grown here. It is described as follows by Mr. Joseph H. Paschell, of Ward, Delaware county: "The Pyle apple originated in Thornburg, Delaware Co., is very closely allied in characteristics to York Imperial, but is a decided improvement, being better colored and smoother shaped, bears better and sells better." Smokehouse seems to be the leading market apple. Bartlett the leading pear. Elberta the most profitable peach.

ELK COUNTY.

Apples, pears and grapes do well. Only the hardiest kind of native peaches are grown. Japan plums succeed in favored localities. All sorts of cherries can be grown. Fruit is very uncertain on land less than 600 feet above the creek level, as late and early frosts kill the buds. Apples can be grown on land 100 feet above creek level, which is about 1,200 feet above sea level. All the late winter varieties should succeed in this elevated country.

ERIE COUNTY.

All kinds of fruit succeed, and large quantities are grown and shipped out of the county. The grape belt has a world wide reputation for the quantity and quality of its product. Fine Baldwin, Spy and King apples are sent from here as can be found anywhere, but they ripen early and are generally marketed before the holidays. Canning factories take large quantities of cherries, plums, peaches, Kieffer pears (which are sold to the public in cans labeled Bartlett), quinces and currants. All varieties of plums and all varieties of cherries succeed. Grape growers are making their principal plantings of Concord, Niagara, Moore's Early and Delaware. It is a poor peach county generally, but in certain parts of the grape belt are found some fine orchards.

Corry is a poor section for fruit, being too far from the lake shore. At Platea many vineyards are being pulled out on account of grape rot. Growers are just beginning to spray.

FAYETTE COUNTY.

While fruit cannot be profitably grown for market in many parts of Fayette county on account of the fumes from the coke ovens which injure its appearance, yet on elevated land away from the coke ovens, all kinds of fruit can be profitably grown. Most varieties of winter apples ripen in the fall, but York Imperial and Rome Beauty can be grown for late winter. Baldwin and Grime's Golden for early winter. Northern Spy ripens in the fall and drops from the tree before maturity. Peaches, plums and cherries must be planted on high ground to escape late frosts.

FRANKLIN COUNTY.

Franklin county is destined in the near future to become the apple orchard of Pennsylvania. Large plantations have recently been made of Ben Davis and York Imperial, and others still larger are in

contemplation. Smokehouse, Grime's Golden, Smith's Cider and York Stripe have been grown with profit. Baldwin and Northern Spy ripen too early and drop their fruit before maturity. Mid-season and late peaches have given the best money returns. The proper elevation for both peaches and apples seems to be from 100 to 200 feet above the lowest point of the valley or 600 to 800 feet above sea level. The surface is very much broken, the soil on many of the lower ridges and elevated valleys is a mixture of limestone slate and ironstone, which is seldom found outside of this belt. Here the finest peaches are grown. On the higher altitudes the soil is principally disintegrated mountain rock, mixed with considerable copper ore, which is claimed to be an ideal soil for apples, and justly so, for apples grown on these ridges ripen much later than those in the valley and are unusually fine and high colored.

All kinds of orchard fruit and all kinds of small fruit do well. The demands of the market should determine the selection of varieties, as all seem to grow equally well.

FOREST COUNTY.

This county is undeveloped. The information obtainable on the subject was very meager. Apples, pears, plums and grapes can be grown, also peaches in favored locations, but up to this time have only been grown for home supply.

FULTON COUNTY.

All kinds of both orchard and small fruit can be grown in Fulton county. Owing to its southern location, special care must be taken to plant above the fog and frost line. It is especially adapted to apple culture. Orchards planted on the red gravel ridges have done very well. The county is as yet undeveloped, owing to the fact that it has no railroad within its borders. There is a road, however, in contemplation ,and when this is built there is no reason why apple and peach culture should not be two of the most profitable industries in the county.

GREENE COUNTY.

The high lands of Greene county are well adapted to all kinds of fruit. Apples have been grown for some time successfully in small farm orchards and the peach orchards that have been planted in recent years on high ground have succeeded. Owing to its southern location the matter of altitude is very important. The level and low lands are apt to suffer severely from late frosts. Grapes, plums and cherries do well and small fruits ought to be profitable, as there are a number of good markets within easy reach by rail.

HUNTINGDON COUNTY.

Very few large orchards of any kind are to be found in the county, although the farms are well supplied with a variety of fruit for home use. All kinds do well when planted on high ground that is deep and has a good sub-soil. An orchard of Simpson plum, on the farm of Mr. A. A. Simpson, near Mill Creek, planted in 1880 and 1885 has been yielding profitable crops since 1890; this is a new variety that originated in Mercer county, Ill. It is hardy, a good bearer and shipper, has free seed and is a good seller. Peaches do well on high ground. Small fruits can be grown, but the nearby markets are well supplied with wild blackberries and raspberries from the woods, which sell very cheap during the height of the season.

INDIANA COUNTY.

No attention has been paid to fruit for commercial purposes. The soil of the valleys is principally heavy clay which is not adapted to the purpose. Apples, peaches, pears and grapes can be grown on the high ground. Japan plums that have been planted on high ground with a good sub-soil promise well. There are plenty of good locations for orchards in the county, but railroad facilities are very poor, except in a very small section, and while this condition continues there is little inducement to plant.

JEFFERSON COUNTY.

Little attention was paid to the subject of fruit prior to 1890. Since that time a few orchards have been planted with good results. On the higher elevations all kinds of fruit do well, and there is a good home market in the different mining towns, both for orchard and small fruits at high prices. The most profitable apples are Baldwin, Spy, Rambo and Fallawater; in peaches, Elberta, Wonderful and Champion have been the money makers. European plums of all kind rot badly. Burbank and Abundance are being tried, but no bearing trees have been reported. With its high elevation, Jefferson county should produce the finest kind of winter apples.

JUNIATA COUNTY.

The Tuscarora Valley along the foot of Shade Mountain is a fine section for fruit of all kinds. Apples and peaches pay best. Many profitable orchards have been grown and many miserable failures have been reported from what is known as the "Juniata Peach Belt." The principal cause of failure has been that the trees were planted on shallow, slaty hills, where they could not get sufficient moisture

during the summer months. Wherever peaches have been planted on a deep soil above the fog line they have paid well. Owing to the mild climate, apples ripen early and do not keep well, but to offset this they have good railroad facilities to market that take large quantities during the months of October and November. Smoke-house, Summer Rambo and Baldwin can be grown for fall and early winter. Grime's Golden, York Imperial and Rome Beauty for later. The mid season and late peaches have been found most profitable. All kinds of small fruit can be grown, but the markets within easy reach are well supplied with wild berries. For this reason strawberries are the only small fruit grown to any extent in the county.

LACKAWANNA COUNTY.

Considerable attention has been paid to fruit, and many valuable varieties have been propagated, especially is this true of apples. The Bank apple (local), is sub-acid, medium sized, good for eating and cooking, an abundant bearer and ready seller. It ripens in the fall ,and is considered the best of its season wherever grown. The Clark (local) is also much esteemed by all who know it. The level lands do not grow good fruit, but the hillsides and higher ground produce all kinds in perfection. The best apples are Baldwin, Spy, King and Duchesse of Oldenburg. Pears—Bartlett, Clapp's Favorite, Kieffer and Anjou. Peaches—Stump, Old Mixon, Mt. Rose, Crosby and Fitzgerald. Plums—All seem to do well. Small fruits do well. Strawberries are grown principally and hauled by wagon to nearby markets.

LANCASTER COUNTY.

The farmers of Lancaster county have been so much occupied with the production of tobacco and wheat that the fruit industry has been sadly neglected, but there are thousands of acres not adapted to either of these crops that might be planted to orchard with profit. The most popular apples are Baldwin, York Imperial, Grime's Golden, Smith's Cider, Greist's Winter and Krauser. Peaches—Elberta, Globe, Champion, Fox Seedling, Crawford's Late, Mt. Rose and Crosby.

Pears—Bartlett, Clapp's Favorite, Lawrence and Duchesse.

Plums—All kinds do well. Grapes, cherries and quinces are grown for home use in all parts of the county and grow well everywhere. Spraying is only practiced by a few men as plantations are generally too small to warrant the expense of an outfit.

LAWRENCE COUNTY.

Little attention has been paid to fruit for market, but where planted on high ground with a good sub-soil and properly cared for it succeeds well. The most profitable apples are Baldwin, Ben Davis, Fallawater, Grime's Golden and Austin Sweet. Peaches—Crawford's Late, Old Mixon, Smock and Elberta. Plums—German Prune, Damson, Green Gage and Abundance. Cherries—Richmond, May Duke and Black Tartarian. Grapes—Concord, Delaware and Niagara.

LEBANON COUNTY.

Most of this county is well adapted to fruit culture. The best land is on the north side of Cornwall Hill, extending westward to county line. Here we find gravel, sand and what is known as iron-stone land; the best for fruit in the State.

Best apples for Lebanon county are York Imperial, Baldwin, Strinetown Pippin, Dominie, Smokehouse and Yellow Transparent. Peaches—Elberta, Brandywine, Late Crawford, Globe, Mt. Rose, Stump, Old Mixon, Fox Seedling. Pears—Bartlett, Clarigeau, Lawrence and Kieffer. Plums—Wild Goose, Abundance, Burbank, German Prune, Prince Engelbert, Lombard. Cherries—Napoleon, Yellow Spanish, Tartarian, Gov. Wood, Hortense, Richmond, Montmorency. Grapes—Concord, Worden, Niagara, Clinton.

Small fruit culture is undergoing a change in this as in other counties. Small plantations are being started all over the county, near the manufacturing and mining towns, and the large growers are going out of business.

LEHIGH COUNTY.

The mountains run east and west and contain a variety of soil. Some very poor, but some very good fruit land. Apples, pears, plums, peaches, cherries and small fruits are grown for local market, but none are shipped out of the county. All kinds of fruit do well on the high lands. The leading apples are Smith's Cider, Baldwin and Smokehouse of the older sorts. A number of local varieties are grown with profit, among which are Hundwerk and Herter, which originated in Heidelberg township. Both are winter varieties, long keepers, sub-acid, red-streaked, fair sized, good bakers and good sellers. Recommended by L. B. Geiger, of Hoffman. Baer or Hiester originated in Berks county, a heavy bearer and late keeper. Lehigh Greening, a large, greenish-yellow fall apple, sub-acid ,a heavy bearer and good seller. Large Yellow Pie is a large early summer apple of first quality, slightly sub-acid, a heavy bearer. These have been recommended by Henry F. Rupp, of Seips-

town and W. B. K. Johnston, of Allentown. The leading pears are Bartlett, Seckel, Anjou and Kieffer. Many old pear trees of the Calabash and "Seed Time" varieties are still found in good bearing condition, from 90 to 100 years old, but as they die out they are being replaced by better and more modern varieties. In peaches, we find Elberta, Champion, Early and Late Crawford, Wheatland, Smock and Mt. Rose.

Both European and Japan plums seem to do well where properly cared for. Several orchards of both apple and peach have been planted during the past year, and interest in fruit seems to be growing all over the county.

LUZERNE COUNTY.

Very little attention has been paid to fruit. There is a good local market for fruit of all kinds. On the higher altitudes high grade winter apples can be grown, and summer and fall apples for the local market do well in every portion of the county. Cherries and peaches succeed in many places. Plums have, as a rule, proved a failure. This, however, seems to be due to destruction by the curculio and ignorance of preventive measures, rather than to any climatic or soil conditions. The leading apples are Baldwin, Rhode Island Greening, Smith's Cider and Smokehouse. Pears—Bartlett, Clapp's Favorite, Seckel and Duchesse. Peaches—Crawford's Early, Elberta, Champion and Mt. Rose. Cherries—Gov. Wood, Tartarian, Napoleon, Montmorency and Richmond. Grapes—Worden, Concord, Moore's Early, Niagara and Delaware. The principal drawback to orchard culture in the mining region is depredation by small boys and idle characters always found loafing around public works.

LYCOMING COUNTY.

Apples can be grown successfully in most sections. Peaches and plums will succeed if planted on very high ground with a northern exposure. Otherwise they are apt to be killed by late frost. No attention has been paid to commercial fruit culture. Apples are recommended for the general market, other fruits for local market only. Small fruits produce enormously if properly cared for. The most popular apples are Baldwin, Smokehouse, Spy, R. I. Greening, Smith's Cider and Grime's Golden. Pears—Bartlett, Seckel and Kieffer. Peaches—Mt. Rose, Elberta, Early and Late Crawford, Smock and Salway.

McKEAN COUNTY.

No better place can be found for apples and pears. Some peaches are grown on the hills, but most of the trees are young and have not yet been proven.

Sour cherries do well. Blue Damson is the only plum grown to any extent, but other varieties will succeed if properly cared for. The leading apples are Baldwin, Spy, King, R. I. Greening, Grime's Golden. Pears—Bartlett, Anjou, Clapp's Favorite, Sheldon.

Little attention has been paid to small fruit culture, because wild berries are so plentiful on the mountains and so cheap in the markets. Growers are beginning to spray their apples, and to pay more attention to their orchards. The indications are that in a few years large quantities of apples will be raised in McKean county for export. Where the trees are properly cared for the flavor is delicious and the quality of the fruit unsurpassed.

MERCER COUNTY.

Apples are the principal fruit, but peaches and plums do fairly well, both sweet and sour cherries, pears and grapes are grown successfully for home use. The leading apples are Baldwin, Spy, Hubbardson and York Imperial. In addition to these, a number of varieties have been profitably grown. Stark, Mann and Winter Blush, for winter, Mammoth Pippin (ripe Sept. and Oct.), and Congress Pippin (ripe Nov. to Feb.), for fall, have been tried by Mr. A. B. Greenlee, of New Lebanon, and are pronounced by him, along with the four first named, the best out of forty varieties growing on his farm. He also names the Crosby peach as the best and most profitable.

The best peach orchard is planted on a ridge from which chestnut, oak and hickory had been cut, at an elevation of about 1,200 feet above sea level, 100 feet above creek level.

MONROE COUNTY.

The best part of the Mt. Pocono region is in this county. All kinds of fruit do well, but care must be taken in selecting location for peaches, plums and cherries on account of early frosts in fall and late frost in spring. The leading apples are Baldwin, York Imperial, Stark, Duchesse of Oldenburg, King and R. I. Greening; Stayman's Winesap has been fruited two seasons and gives promise of great value. The leading peaches are Elberta, Crosby, Old Mixon Free, Triumph, Mt. Rose, Early and Late Crawford, Chase Early and Reeve's Favorite. The very early and very late varieties are not profitable.

Very few plums are raised, but where properly cared for the following varieties have done well: Lombard, Wild Goose, Abundance, Burbank, Satsuma, Berkman and Red June. Cherries do well wherever apples succeed. Black Tartarian, Florence, Napoleon, B. Early Richmond, Louis Philip and Montmorency have been grown

with profit. The leading pears are Bartlett, Seckel, Manning's Elizabeth, Howell and Kieffer.

From reports furnished, we believe much of the high land could be profitably planted with peaches, as they grow well and the market for them is good. Winter apples of high grade can certainly be grown with profit.

MIFFLIN COUNTY.

The climate is too mild for high grade winter apples. It is well suited to peaches, pears, summer and fall apples, plums and grapes. All kinds of fruit grow well if properly cared for. The county is composed of a number of narrow valleys running back from the river, between ridges of varying height. On the ridges and some of the elevated narrow valleys are to be found many pockets of excellent fruit soil, deep and rich in mineral food; also a great many stretches of thin slate land. Many farmers have made the mistake of planting peaches on this thin slate land and after several years of work and waiting, dug up their trees in disgust and declare that there is no profit in fruit. Yet no finer peaches have ever been grown than those raised in properly located orchards in Mifflin county. The leading apples are Baldwin, Ben Davis, York Imperial and Rome Beauty for winter, Smokehouse and Maiden's Blush and Northern Spy for fall, Early Harvest and Summer Rambo for summer. The leading peaches are Elberta, Late Crawford, Mt. Rose, Chair's Choice, Beer's Smock, Globe and Stump. The leading pears are Bartlett, Clapp's Favorite, Flemish Beauty, Seckel and Kieffer. The leading plums are Lombard, Wild Goose, Burbank and Abundance. Cherries—Gov. Wood, English Morello and Early Richmond.

MONTGOMERY COUNTY.

This being a dairy county, little attention is paid to fruit. There is a great variety of soil and much good fruit land that could be utilized. All kinds of fruit do well on high ground, and local markets are plenty. Strawberries are raised to some extent for the Philadelphia market. A number of peach orchards are being planted. Many farmers are still plowing and planting steep hillsides in farm crops at a loss, which could be planted to apples, pears and peaches with profit.

MONTOUR COUNTY.

Practically no attention has been paid to commercial fruit culture, but from its location and elevation we would judge that all kinds of fruit can be raised, the altitude being from 700 to 1,000 feet above sea level.

NORTHAMPTON COUNTY.

The soil seems to be naturally adapted to all kinds of fruit, but the business is very much neglected. The best apple orchards are planted at the base of the mountains. The winter varieties, Baldwin, Ben Davis, Belleflower, Smith's Cider and Peck's Pleasant, are most profitable. The summer and fall varieties are not so desirable. Few peaches are grown. Beer's Smock, Reeve's Favorite, Champion, Globe, Late Crawford and Old Mixon Free have been tried with moderate success. Bartlett, Seckel, Clapp's Favorite and Kieffer pears have been grown. From reports furnished it would seem that the only fruit that has been grown with much profit is the winter apple.

NORTHUMBERLAND COUNTY.

Farmers are just beginning to take proper care of their orchards. They have the soil and location suited to the growth of all kinds of fruit, and the local markets in which to sell. In addition, they have excellent railroad facilities to reach markets more remote. The best orchards are found on the ridges on either loam, red shale or gravel soil. The leading apples are Baldwin, Smokehouse, Belleflower, Summer Rambo, Yellow Transparent, Northern Spy, Early Harvest and Maiden's Blush. The leading pears are Bartlett, Clapp's Favorite, Flemish Beauty, Sheldon and Kieffer. Peaches—Early and Late Crawford, Old Mixon, Foster and Mt. Rose. Plums—Green Gage, German Prune, Wild Goose, Purple Niagara and Abundance. Some small fruits are grown for local market, but none are shipped out of the county.

PERRY COUNTY.

This should become one of the leading fruit counties of the State. It is crossed by several mountain ranges, between which are found elevated valleys and moderately sloping hills, with deep, sandy and loamy soil, often filled with broken stone rich in iron, on which all kinds of fruit will grow in perfection, but especially apples and peaches. It has good railroad facilities for reaching all parts of the State. The farmers are beginning to realize their advantages and are planting extensively in some sections, but have not given their orchards the attention they require.

Owing to the mild climate, all fruit should be planted on high ground. Apples grown from 100 to 500 feet above the level of the Juniata river keep better than those grown on lower land. It is a great country for cherries. All kinds, both sweet and sour bear enormous crops, but little attention has been paid to the finer sorts. The leading apples are Summer Rambo, Smokehouse, Baldwin,

Maiden's Blush and York Imperial. Peaches—Elberta, Late Crawford, Globe, Old Mixon and Stump. Salway does well in certain places. The leading pears are Bartlett, Seckel, Duchesse and Clapp's Favorite.

PIKE COUNTY.

Owing to its high altitude, Pike county is especially adapted to the production of winter apples of highest grade. Here can be grown Northern Spy, Baldwin, King, Spitzenburg, Grime's Golden and Gilliflower. No attention is paid to orchards. The trees simply grow wild, and produce the finest fruit. Most varieties of pear do well. Bartlett, Seckel and Duchesse can be easily grown. Plums and cherries succeed in some places, but peaches are uncertain.

POTTER COUNTY.

The industry is undeveloped. Apples, pears and plums succeed as far as tried, on comparatively low land as well as elevated. Peaches have not been grown to any extent. Red Astrachan and Early Harvest apples are grown for summer, King, Baldwin and Spy for winter.

SCHUYLKILL COUNTY.

The character of the soil varies greatly according to the geological formation. The mountain ranges trend N. E. and S. W. Fruit has been planted to some extent on the ridges between the mountains, at an altitude of from 500 to 900 feet above the Schuylkill river, with fair success. The peach orchards are located on the eastern slopes and level uplands formerly timbered with chestnut, while apples are doing better on the lower levels where the soil is rather deeper and more clayey. At present fruit is only grown to supply local demand at the mines. None is shipped out of the county. The land seems to have little natural fertility, it is too porous on the hills, while on the low lands is usually found a tenacious clay resting on an impervious hard pan. The leading apples are Baldwin, Smokehouse, Summer Rambo, Grime's Golden, Winesap and Maiden's Blush. Pears—Bartlett, Clapp's Favorite, Seckel and Kieffer.

Peaches—Iron Mountain, Elberta, Mt. Rose, Early and Late Crawford, Old Mixon and Stump. Plums and Cherries are not grown to any extent for market, being liable to insect injury, rot and black knot. Only sour cherries and seedlings are grown. There is little demand for quinces, and none are grown outside of gardens.

SNYDER COUNTY.

On the ridges of Snyder county is found deep, black ironstone soil, strongly impregnated with iron, which is the very best for peaches. Large orchards have been planted in recent years, many of which have already come into profit. On these ridges the later varieties of peaches can be grown. Salway has been planted in large quantities, and is pronounced the money maker. The following are also grown with much profit: Bilyeus Late October, Smock, Fords, Chair's Choice, Elberta, Stump and Beer's Smock.

Apples are only grown for home consumption, but the soil and climate seem well suited to them, especially the fall and early winter varieties. Summer Rambo, Smokehouse, Baldwin, Yellow Transparent, Red Astrachan, York Imperial and Belleflower have been grown successfully. The leading pears are Bartlett, Clapp's Favorite, Lawrence and Kieffer. The leading plums are abundance, Burbank and Imperial Gage. Cherries—Black Tartarian, Windsor, Montmorency and Early Richmond. Small fruits are grown by a few farmers for market, but the plantations are small and only worked as side issues. A few intelligent, energetic men have planted orchards, and by their judicious care have made them so profitable that quite an interest has been manifested lately all over the county, and if the same good judgment is exercised in the selection of sites for orchards as was shown when the first were planted, Snyder county is destined to make a name for herself shortly in the fruit markets of the country.

SOMERSET COUNTY.

With its rolling surface and many high hills, Somerset county furnishes many excellent locations for orchards. Owing to distance from market, little attention has been paid to commercial fruit culture, but mining towns that have sprung up within recent years, offer a good home market and orchards are being planted. If care is taken to plant above the frost line, all kinds of fruit can be grown to perfection. On the higher altitudes the Albemarle Pippin succeeds, and there is no more profitable market sort. Baldwin, Northern Spy, Twenty Ounce and Early Harvest succeed well, also a native seedling, called Spice Apple. The latter beings ripening in August and continues ripening until October and can be kept until March. It has a very rich, aromatic and acid flavor and is a good cooker.

The leading peaches are Alexander, Early Rivers, Mt. Rose, Champion, Lemon Free and Stump. Plums—Lombard and German Prune. All kinds of cherries do well, but no attention has been paid to the finer sorts. Concord, Worden, Salem, Niagara and Moore's Early grapes do well , if planted above frost line. If care is not taken in

this, the blossoms are apt to be killed by late frosts, and this is true of all other fruit, even apples.

SULLIVAN COUNTY.

The timber has just been removed from the greater part of the land, and farmers are only beginning to turn their attention to agriculture. Owing to its elevation, winter apples of high grade can be grown. Baldwin, Northern Spy, King, R. I. Greening, Spitzenburg and Grime's Golden should succeed well. Peaches are flourishing at an altitude of 1.500 feet above sea level. Freight rates are very high, as there is only one railroad in the county. Another road, however, will most likely be built soon. This will cause competition and freight rates will be lowered.

SUSQUEHANNA COUNTY.

This is a dairy county. Very little attention has been paid to commercial fruit culture, as freight rates are very high. The soil and climate are well suited to apples and pears. Peaches, plums and cherries are uncertain. Baldwin, Northern Spy, R. I. Greening, Gilliflower and King apples flourish and produce large crops of the finest fruit without special care. The industry cannot be made profitable unless lower freight rates can be secured.

TIOGA COUNTY.

This is not a peach county, although more peaches could be grown if attention were paid to location of the orchard. The red shale lands which abound in the county produce high colored, fine flavored apples, the very best of their kind. Plantations for market should contain high grade winter sorts, such as Baldwin, Spy, Hubbardson, King, etc. No sweet apples are grown as they do not sell well on the general market. Pears can be grown, also European and Japan plums, and both sweet and sour cherries. Orchards are very much neglected.

UNION COUNTY.

Farmers are engaged in raising cereal crops, and do not pay any attention to fruit. Many grow enough for family use, and sell the surplus in the nearest market. Many hillsides and elevated fields offer excellent sites for orchards, with congenial soil and climate. Some peaches are grown for market.

The leading apples are Baldwin, Smokehouse, Early Harvest and Red Astrachan. Pears—Bartlett, Clapp's, Seckel, Kieffer. Peaches—Alexander, Early and Late Crawford, Mt. Rose, Elberta, Stump, Old Mixon and Fox Seedling. Plums—Imperial Gage, Peach, Abund-

ance, Burbank, Red June and Satsuma. Cherries—Coes Transparent, Early Purple Guine, Montmorency Ordinary, English Morello, Richmond. Grapes—Concord, Delaware, Catawba, Niagara.

VENANGO COUNTY.

No attention has been paid to the cultivation of fruit. Farmers grow enough for their own use. There are a few small orchards that supply local markets. The soil and climate is suitable for apples and pears. Peaches are uncertain, as the winters are cold, the thermometer often falling to 15 degrees below zero. They are grown in small quantities in favored locations.

The following varieties have been grown. Apples—Baldwin, Northern Spy, Red Astrachan, King, Twenty Ounce, Duchesse of Oldenburg, Early Harvest. Pears—Bartlett, Clapp's Favorite, Kieffer and a local variety named Koonce, which is very large, ripens in August and sells well in the local markets. Peaches—Champion, Crosby, Elberta, Late Crawford, Old Mixon and Mt. Rose. Plums—Abundance, Burbank and German Prune. Grapes—Concord, Moore's Early, Niagara and Catawba.

WARREN COUNTY.

This is an oil region. No attention has been paid to fruit. A few orchards have been planted quite recently, which give promise of success. Apples do well wherever found in the county, but freight rates are so high that farmers are deterred from planting on a commercial scale. With a canning factory to utilize their product the fruit industry might be made profitable, as apples, pears, cherries and plums of the finest kind can be grown with proper care and attention.

WASHINGTON COUNTY.

The farmers of Washington county have given their attention almost exclusively to the raising of sheep, and have neglected fruit altogether. Many of the hillsides and hilltops could be profitably utilized by planting in orchards and the two industries flourish well together. No better plan of management can be adopted for an apple or pear orchard, than to seed it down to grass when it has reached a bearing age and pasture it with sheep. Farmers are beginning to plant apples, peaches, pears and plums. Owing to the mild climate, winter apples, such as Baldwin, Spy and King ripen in the fall, so that care must be taken in the selection of location. Peaches, pears, plums, grapes and small fruits when properly cared for seem to do well and promise to make profitable returns. The

leading apples are Rome Beauty, Grime's Golden, Rambo, Northern Spy, Yellow Transparent, Duchesse of Oldenburg and Summer Rambo. Pears—Bartlett and Kieffer. Peaches—Elberta, Champion, Mt. Rose, Late Crawford, Stump and Old Mixon. Cherries—Yellow Spanish, Black Tartarian, Early Richmond. Leading plums are Damson, Lombard and Shipper's Pride.

WAYNE COUNTY.

This is a dairy county, but altitude and soil are so favorable to apples that we find them growing wild in the pastures and on the hillsides. The finest winter varieties can be grown. Peaches can be grown if proper location is selected. Fruit trees are not cared for, and the fruit is roughly handled and carelessly packed. As a consequence prices received for Wayne county fruit have not been satisfactory, and the shippers have become discouraged. If the apple trees now standing in the county were properly cared for, and the fruit carefully graded and packed, it would command top prices in any market. The leading apples are Baldwin, Northern Spy, King, Hubbardston and Duchesse of Oldenburg. In addition, Mammoth Pippin, Seek-no-farther, Black Gilliflower, and Cooper's Market are highly recommended. York Imperial is on trial, but too young yet to bear. The leading peaches are Triumph, Globe, Old Mixon, Crawford's Early, Elberta, Crosby and Crawford's Late. These have all been successfully fruited by Mr. E. E. Avery, of Dyberry, whose orchard is planted on gravel soil 1,800 feet above sea level, and about 200 feet above water level, and who, after years of experience raising and dealing in fruit, believes that Wayne county is a very good place to grow fruit for market, especially winter apples.

WESTMORELAND COUNTY.

Owing to its altitude above sea level, winter apples of high grade can be grown. Peaches can be grown on carefully selected locations. Also cherries, Japan plums and European plums. Little attention has been paid to fruit, but a few commercial orchards have recently been planted, which are not yet in bearing. The soil in the valleys is principally limestone clay, while on the upland, it is more sandy. The best fruit and the largest crops of fruit are grown on these sandy uplands. The leading varieties of apples are Baldwin, Rambo, Ben Davis, Maiden's Blush, Spitzenburg, Early Harvest and Winesap. York Imperial is on trial in many places, but trees are mostly too young to bear. Pears—Bartlett and Kieffer. Peaches—Elberta, Crawford's Early and Late, Mt. Rose, Old Mixon and Crosby. Plums—

Abundance, Green Gage and Wild Goose. Cherries—Black Tartarian, May Duke, English Morello and Early Richmond.

WYOMING COUNTY.

What are known as the "Hill Lands" are well adapted to all kinds of fruit. Frost, mildew and blight, injure trees planted on low ground. There are good local markets for all fruit grown and much more attention should be given to the industry. The leading apples are Baldwin, Northern Spy, Ben Davis, R. I. Greening, Gilliflower, Red Astrachan and York Imperial. Pears—Bartlett, Seckel, Flemish Beauty and Kieffer. Peaches—Crosby, Elberta, Old Mixon and Mt. Rose.

YORK COUNTY.

The range of low mountains known as the York Hills, which traverse the county in a southeasterly direction seem to furnish all the conditions of soil and climate needed to grow apples, pears, peaches, plums, cherries, and all the small fruits to perfection. On these ridges we find a great variety of soil, but what is known as the iron stone land produces the best fruit, especially peaches. The San José or Pernicious Scale has caused great havoc among orchards all over the county and growers are much discouraged. The leading apples are York Imperial, Grime's Golden, Ben Davis, Smokehouse and Yellow Transparent.

Pears—Bartlett, Clapp's Favorite and Kieffer. Peaches—Mt. Rose, Elberta, Early and Late Crawford, Globe, Smock, Stump, Fox Seedling and Salway. Plums—Wild Goose, German Prune, Green Gage, Abundance and Burbank. Cherries—Napoleon, Gov. Wood, Black Tartarian, Richmond and May Duke. Grapes—Concord and Niagara. Harrisburg and York furnish two excellent markets for all the fruit that can be grown, and the industry was in a very flourishing condition before the appearance of San José Scale.

THE NATURAL IMPROVEMENT OF SOILS.

BY EDWARD B. VOORHEES, M. A., *Director of the New Jersey Agricultural Experiment Stations.*

The farmer's primary source of income is the soil; the success of his operations, therefore, depends upon its original composition and character, its management and the handling of the products raised. The management of a soil, however, is quite as important a factor as the character of the soil itself, for it may be directed in such a way as to result either in rapid impoverishment, or in great improvement in productivity. In other words, the man is the most important factor in farming, as in other lines of business.

How Soils Differ.

In studying the nature of soils, we find that they possess two distinct characteristics, which have a direct bearing upon their fertility, or crop-producing power; one of these characteristics is the chemical, or the power which soils possess of furnishing those constituents that are necessary in the growth of plants, though it is not necessary that soils, perfect from the chemical standpoint, that is, that can furnish an abundance of the essential plant-food constituents for all kinds of plants, shall contain the constituents in the same proportion as they are found in plants. In fact, because of the origin and nature of soils, those constituents which are contained in them in maximum amounts are found in plants in minimum amounts, while on the other hand, those constituents which are contained in plants in maximum amounts are found in minimum amounts in soils, thus making the value of a soil from the chemical standpoint dependent rather upon the relative amounts of the four constituents, which by the continuous growth of plants are removed more rapidly from the soil than the others, viz: Nitrogen, phosphoric acid, potash and lime. These are, for this reason, called essential manurial constituents, and the wide differences in soils in respect to their content of the substances which furnish them are due to the changes which were wrought in the surface of the earth during its formation, to those which have taken place since, as well as to those which are going on in a small way even at the present time.

It is believed that the original earth crust contained all the minerals now found in it, and that at the beginning they were distrib-

uted more uniformly throughout its mass than at present. In the harder rocks, the sandy particles were cemented together by materials more easily disintegrated and the separation thus made in the course of time enabled the movement of the particles so separated in a different way, the coarser materials were distributed and deposited as gravel and sand in one place, and the finer carried and deposited in another, making the clay; the lime entered partly in solution, and was distributed and finally deposited in another place, thus giving us sandy, clayey and limy soils, all differing from each other in their amount and proportion of both the purely mechanical substances, which serve no other purpose in soils than the support of the plants and in contributing to physical character, and of the chemical substances which contain the essential fertilizing constituents, and which in their decay provide the food in an available form.

In addition to these kinds of soils, there are others of more recent origin, made up largely of vegetable matter, due to its accumulation in a partially decayed state; these are frequently rich in nitrogen and poor in all of the essential mineral constituents. These considerations as to the origin of soils are valuable in indicating their chemical composition and possible potential value.

Chemical Differences in Soils.

In the next place, fertility depends not altogether on the amount and proportion of the essential constituents contained in soils, but also upon the character of the mineral substances which contain them, that is, whether they are of such a character as to be readily disintegrated or broken down, or whether they are hard and dense, and thus resist those agencies which are active in causing such disintegration. It is quite possible for a soil to be rich in all of these constituents, and still be infertile, because the character of the substances making the soil are such as to prevent their ready attack by those agencies which cause the constituents to become active.

Physical Differences in Soils.

The second valuable characteristic of soils is their physical character. This characteristic is not altogether separate and distinct from the chemical, nevertheless it has to do more particularly with the purely mechanical substances contained in soils and their fineness of division, and has an important bearing upon the actual fertility. In order that we may understand this matter more clearly, it is well perhaps to point out that the substances which constitute the bulk of soils are in an insoluble condition, while the plants

take up their food in a soluble condition, hence changes must take place in these substances before they can serve as plant food. The plant roots themselves assist to some extent in causing this change, thus rendering the constituents soluble, still, the great factor in this change is the action of those natural forces, water, sun and air. Water has a solvent effect upon the constituents of soils, and unless it can freely penetrate and reach every portion of the soil its power is very much reduced. That is, if the soils are so compact and dense as to prevent the free penetration and movement of water in the soil, the plants are not able to readily obtain their food, and thus make maximum growth and development, because enough is not distributed throughout those soil layers to which the plant roots are limited. On the other hand, soils that are too open and porous, that are made up of rather coarse particles of mineral substances, as, for example, sandy soils, made up chiefly of quartz, the water penetrates and moves too freely, and the dissolved constituents that are present are too readily carried away from those parts of the soil in which the plants obtain their food, thus again not providing the best condition for its appropriation.

Furthermore, the reservoirs of water under these soils, or in the subsoils, and which are also extremely essential, are rapidly depleted, as the water escapes very freely from the soil in the form of vapor, and this prevents the plants from obtaining so large a proportion of the water that is stored in the earth, as if the conditions of soils were such as to prevent the free escape from the surface. Between these two extremes of soils, first, those with very finely divided particles, making the soil too compact and thus impervious to water; and second, those that are made up of coarse particles, we may have a mixture of the two, which is probably well represented by what is understood as a loam, which possesses in part the properties of each in such a degree as to make the movement of the water more nearly perfect in respect to its supply to plants. That is, we obtain the solvent effect of the water, as well as the free movement of it, which contributes both to the solution of constituents and their movement throughout the soil where needed. It, therefore, frequently happens that from soils reasonably rich or even very rich in chemical constituents, results are obtained that are far below what might be expected from the composition of the soil, because their physical character is such as to prevent the movement of water, and consequently the necessary changes which make it possible for the plant to obtain its food. These considerations are also true in a degree in reference to the action of the other natural agencies, air and warmth. Only in the case of those soils which possess good proportions of the various substances making up soils, do we receive the full benefit of Nature's aids.

The Biological Character of Soils.

The physical character of soils, also, has an important bearing upon the question of the living organisms in the soil, whose activity in improving soils is very important, though not appreciated until recent years, and not yet fully understood. Soils are not, as has been believed to some extent in the past, dead things, serving only as banks from which we may draw out deposits of materials, already in a state capable of serving as food, but are rather laboratories, in which the natural agencies, already described, are actively engaged in working over the raw materials, converting them into forms available for use. They contain millions of living creatures, small to be sure, which depend for their life upon air, moisture and the insoluble matter in the soil, the latter of which in the transformation which takes place in the growth of organisms, is changed into forms which the plant can absorb.

It must not be forgotten that these lower orders of life depend for their best growth and development upon the conditions that are favorable for the life and growth of the higher orders of life, namely, food, moisture and warmth, and as the farmer by his practice makes the conditions favorable for their life and thus encourages their growth, he provides for a more rapid change of soil substances, while on the other hand, if he by his practice prevents or in any way reduces the opportunities for the life and growth of these agencies, he reduces in just that degree the possible usefulness of the potential fertility of such soil. For example, the farmer who allows his soil by improper treatment to become compact and hard, thus not permitting the free movement of air and water, is making the conditions unfavorable for the living organisms in the soil, and is preventing in part the change of insoluble into soluble substances, the result of which is food for the plant; while, on the other hand, the farmer who by his practice makes the conditions for life in the soil favorable by controlling the movements of water , warmth and air, obtains from his soil a larger crop, because he has directed in an intelligent way the agencies which assist in the change of soil substance, and which is necessary in order to insure an abundance of available food, which assists in the natural improvement of soils. Improvement of soils may, therefore, be brought about, and without expense, by assisting Nature, in changing for the better both the chemical and physical character of soils, and by controlling the movements of the soil solutions. Efforts in this direction may be called "natural methods of improvement," because the aim is to assist Nature in her work which results in changing potential or possible into active, or actual fertility, rather than to add to the soil substances which contribute directly to the store of active constituents.

The Conservation of Moisture.

While the chemical and physical character of soils are of primary importance, and do in a large degree determine the possible productive power of soils, still the handling of the soil possessing these characteristics even in a high degree is of equal importance. That is, a soil however perfect as a place for the growth of plants, or however rich in the plant-food elements, cannot be productive without water, and the amount of water that plants may have at their disposal during periods of limited rainfall is measured in large degree by the methods of practice used. This point is of so much importance and has so intimate a bearing on soil improvement that it warrants a rather detailed discussion of the question of the conservation of soil moisture.

Water is one of the most important constituents of plants. If perfect growth and development are to be attained, it is necessary that the plant shall be able to obtain a full supply during its entire period of growth. It is not simply a question of water, however, for the water that plants use must exist in a special form in the soil, and it must exist there in proper amounts. Soils may contain too much or be too wet for the proper growth of the most useful plants, if the water is not located in the right place. Water exists in soils in three forms; first, free, or running water, or bottom water, or that which fills the soil, and rises and falls as it is increased or decreased by more or less percolating into it from the rains—the point to which it rises is called the water level; second, capillary water, or that held by the adhesion to the soil particles, and which fills the openings between the particles; and third, hygroscopic water, or that held firmly by the particles of soil. Land is too wet for growing plants if there is too much free or running water, or if the water level is near the surface, as it prevents the circulation of the air and the penetration of the roots to sufficient depths.

Plants do not, as a rule, use the running water; they are able to obtain all they need when land is moist rather than wet. For this reason the water in soils useful for plants is usually referred to as the moisture rather than the water of the soil. This moisture of the soil is really, therefore, the capillary water, or that held by adhesion to the soil particles, and while there may be too much capillary water in soils for the best development of plants, because certain kinds of soils may absorb too much, it is not usually a serious matter, because the difficulty can be readily remedied, as will be pointed out later.

The hygroscopic water is that which is very slow to escape, in fact, it must be driven out of the soil. That is, soil which appears to be absolutely dry may still contain this hygroscopic water, and

in order that it may be perfectly dry, it must be driven out by heating the soil up to the temperature of boiling water for a considerable period of time—at this temperature (212 degrees Fahr.) the water vaporizes and escapes into the air. Naturally, this form of water in the soil is not a useful one for plants, as it exists in soils after plants have perished for lack of moisture.

Rainfall the Source of Soil Water.

The water in soils is due to the rainfall; the water-level in the earth rising in seasons of greatest rainfall, or wet periods, and falling in dry periods, hence, while the water that plants obtain is due to rainfall, it does not follow that it shall occur immediately preceding or during the season of the plant's growth. For example, there are places where the rainfall in the course of a year is so great as to provide such a total excess of water as to cause the soil to be thorougly saturated, or to keep the level so near the surface as to prevent the growth of plants, yet luxuriant crops are grown in these places. This is explained on the ground, first, that while the average rainfall is so great as to cause the soil to be thoroughly saturated, the time of the rainfall is such that during the crop making season a sufficient amount only is provided for the plants; that is, that which falls during the season that crops are not growing partly sinks into the soil and partly runs off, and by the time the crop-season is ready, the water level is lowered sufficiently to enable the plants to throw their roots deeply, and they are fed with the capillary water drawn from the reservoirs below, which were filled by the preceding rains; and second, though the rainfall may be, on the average, too great, the soil is of such a character, open and porous, as to enable the rapid percolation of it to lower levels, and the climate such as to cause a rapid evaporation of it into the atmosphere. The moisture that may be obtained from rainfall is, therefore, influenced by two conditions, the time of its precipitation and the character of the soil upon which it falls.

An Even Distribution of Rainfall Desirable.

The water from the immediate rainfall to be most useful to plants should be distributed evenly throughout the growing season; in such cases, a minimum precipitation would provide for a maximum production, if the soil is of such a character as to retain and hold that which falls upon it for the use of the plants. Therefore, while rain is the primary source of water to plants, needed amounts may be obtained from underground supplies. That is, the season of rainfall may occur during the time when plants are not usually growing, but the water sinks into the soil which holds it as in a reservoir,

and as the plants grow the moisture is gradually drawn to the surface by the influence of capillarity, and the amount necessary for full production is obtained, and while its original source is the rainfall, the immediate supply to the plant is derived from that which has fallen a considerable time previous to the period of growth of the plant.

Wet and Dry Seasons.

In countries and States where the year is divided in respect to rainfall into a rainy season and a dry season, the above considerations are well understood, and methods of practice which shall result in the conservation of moisture are of the greatest importance. In what are called the humid regions of the country, the crop does depend in many cases more largely upon the immediate rainfall than upon that which has fallen previously, and in these regions there are seasons when periods of drouth intervene, which make it necessary that a study should be made of the causes which contribute to the rapid escape of water from the soil, and thus make the supplies insufficient to furnish plants with what they need during the growing season.

The Loss of Water From Soils.

Water escapes from the soil by rising to the surface, where it is vaporized, absorbed by the atmosphere and carried away by the wind. The escape of water is, therefore, principally due to capillarity, for as the dry air passes over the surface of the earth, as well as circulating through the surface area, it absorbs all the moisture it comes in contact with; more moisture then rises from below to take its place, and so on until only the hygroscopic water is left in the surface, or within the reach of the roots.

It has been observed that all soils in the same climate do not become dry at the same rate. That is, one soil will remain wet, another reasonably moist, and another absolutely dry, as far as plant growth is concerned, and these in many cases may all be located on the same farm. These differences are due to the character of the soil, or the particles that constitute it, which have a greater or less power of retaining or holding fast to the moisture contained in it. Or, in other words, the character and texture of the soil influences the rate at which the water will escape. By character of the soil is meant its composition, both in reference to the minerals that are contained in it, as well as the size of the particles of which it is composed, or its texture.

A clay soil will hold water more tenaciously than a sandy soil. The clay soil is composed largely of a mineral known as silicate of

alumina, capable of very fine division and close compaction; the sandy soil, on the other hand, is usually made up largely of quartz, a substance hard and stony, and not easily compacted. The clay, which is more finely divided and does not consist of stony particles, can be compacted so closely as to prevent the rapid escape of moisture, whereas the sandy cannot be readily compacted; it falls away again after pressure and the air and water circulate freely through it. As a broad, general rule, the finer the texture of a soil, the more retentive of moisture it is, and the coarser the texture the more readily will the water escape from it. In the first place, then, the greater or less retaining power of soils for water is due to their physical character, and in order to increase or decrease their retentive power their texture should be changed.

It must be remembered, however, that there is such a thing as a soil being too compact from the standpoint of moisture to plants, because this fineness and compactness prevent the ready penetration of the moisture into it; whereas, the open, porous soil permits its ready penetration, thus the one will, because of its compactness, result in the water flowing off rather than into it, and hence it will not always have as much moisture at a certain definite time after rainfall as the one which is more open and porous, and which permits a larger direct absorption and a ready percolation into the lower layers or reservoir below. Therefore, in the study of soil moisture in reference to the plant's needs, improvements of physical character are found to be of service, both in the humid and semi-humid districts, as well as in the arid or semi-arid, where irrigation is practiced; in the case of the easily compacted soil, to enable a greater absorption of that which falls and in the open, porous soil, to cause a greater retention of that which is absorbed.

The improvement of clay, or finely divided soil, should consist of such operations as will separate the particles, and make the soil more open and porous; this may be accomplished by the introduction into the soil of such substances as will coagulate, or bring together the fine particles, thus making the soil more porous. For example, liming a clay soil does improve its physical character and makes it more absorptive; it seems to have the power of collecting the very finely divided particles and partially cementing them into masses, and making the particles larger, thus making the openings between them greater, which permits a readier penetration into them of water and air. So, too, the introduction of vegetable matter, as coarse manures, influences and improves clay soils in this respect; the absorptive power of the soil is increased by the separation of the particles, not only, but because a substance has been introduced into the soil, which in itself has a greater absorbing power.

In the case of the sandy soil the same methods may be used, though the results are directly the opposite of those in the case of the clay. The addition of the lime, for example, has a tendency to cement together and to solidify the stony particles, thus closing up many of the pores and preventing the too rapid percolation of the moisture to lower levels, as well as its rapid escape, while the introduction of vegetable matter improves largely because the matter itself has a greater absorbing and retaining power than the mineral constituents of the original soil.

The aim, therefore, in both of the cases referred to is to get into and to hold in the soils of various kinds the water that falls in the rains, and conserve it for the plant during its entire period of growth. That is, all methods of improvement are based upon the principle that water that is most useful to the plant is absorbed or held by capillary attraction, and that its escape is due to the same cause or capillary attraction. Where water exists in soils in the running or free state, or in a form not useful to plants, where the water level is too near the surface, the improvement then must consist of operations which will lower its level in the soil so that an abundance of room may be provided for the distribution of the roots of the plants, and in order that the circulation of the air may not be impeded, drainage is necessary here, and will be discussed later.

Amount of Water Required by Plants.

The amount of moisture that is consumed by a growing plant is comparatively enormous, that is, the amount of water required for growing a crop is very great in proportion to the dry matter contained in it. On the average, in order to obtain one pound of dry matter in the crop, over 300 pounds of water will be required; that is, over 300 pounds of water must have been obtained by the roots and carried up through the plant and sent into the atmosphere from the leaf surface. Hence, some idea of the very great amount of water that is necessary for the growth of a large crop is gained. For example, a crop of hay from an acre of land, which contains a ton (2,000 pounds) of dry matter, would not be regarded as a large crop, yet in order to obtain it, there would be required over 300 tons (600, 000 pounds) of water, and since plants vary in their needs, the maximum requirements for a pound of dry matter may be as great or greater than 600 pounds, or, in other words, large crops may draw as high as 2,000,000 pounds of water from an acre.

While the object in the conservation of soil moisture is to hold it for use of the crop, it must not be understood that all crops are equal in respect to their requirements. Crops differ widely in respect to their use of soil moisture, depending upon the kind of crop, the length of their period of growth and the object of their growth.

As a broad general rule, the broad-leaved plants and those which do not throw their roots deeply into the earth require more moisture in proportion to the dry matter contained in them than the finer-leaved plants, than those with less leaf surface and whose roots penetrate more deeply into the soil. For example, plants belonging to the grass family, as the grasses, useful for hay, and cereal grains, which do not present so large a leaf surface, and whose roots have a tendency to go deep into the earth, do not use up the moisture as rapidly as the legumes, or many of the vegetables, which have a larger leaf surface. The latter require the maximum amount of moisture in the soil, and suffer seriously immediately there is any lack.

While the total amount of water used may be the same for different plants, the time required for their growth and maturity must also be considered. A crop of wheat, for example, because it requires a longer season for full maturity may obtain its necessary moisture, though the soil contained too low a percentage to enable a potato crop, which grows and matures quickly, to obtain a full supply; a short drouth would not materially injure the wheat while it might ruin the potato crop, because of the difference in the length of the period occupied in the growth of two crops.

Where the object of the growth is succulence, and the leaf or root constitutes the crop, as in the case of many vegetables, as lettuce, beets, etc., an abundant and continuous supply of moisture is of greater relative importance than where the object is maturity, and the seed constitutes the crop, because any delay in growth in the former caused by lack of moisture is accompanied by a reduction in quality, as well as yield; whereas, in the case of wheat or other cereals the influence of delays in growth are more readily overcome, besides the yield rather than quality is affected. These considerations are useful in suggesting kinds of crops to grow under conditions of known rainfall.

A careful review of the principles here pointed out shows the importance of adopting and using methods that will aid as far as possible in retaining in the soil the moisture necessary for the growing plant; or in other words, to so direct it that it may pass through the plant into the atmosphere, rather than directly into it from the surface of the soil.

Conserving Moisture.

To do this, is called "conserving moisture," and many of the operations of the farm, which are now carelessly performed, which result in useless losses of moisture, may be changed so as to make them assist very materially in saving it for the use of the crop, and while

the location of the soil, its character, its composition, its texture and the kind and character of crops all exert an influence, and while the principles as pointed out must be understood, the judgment of the farmer must be exercised in using the various methods that may be suggested, in order that they may apply to the best advantage in his particular case.

What is Meant by Tillage.

In the first place, tillage results in conserving moisture, that is, tillage, while ordinarily performed for the sake of getting the land in condition to receive the seed, and for the sake of removing or preventing the development of foreign growths, may be carried out in such a way as to accomplish not only these objects, the primary purpose in the minds of many, but also to accomplish great things in preventing useless loss of moisture, and thus result in providing the plants with their normal requirements. Tillage consists ordinarily in plowing, cultivating, harrowing and rolling, and each of these operations may be so directed as to needlessly waste soil moistuse, or to conserve it. Just how plowing has an influence in conserving soil moisture is readily understood when we remember that the moisture contained in the lower layers of the soil escapes at the surface of the soil by means of small holes or tubes formed by openings between the particles; in the process of plowing these openings or tubes are broken and the escape of the moisture from below, if not prevented altogether, is considerably retarded until sufficient time has elapsed to form the connection again with the surface. Therefore, it makes a great difference in plowing whether the furrow is thrown in a solid mass or whether when the furrow is turned the soil breaks into fine particles so that the entire surface is really a mass of separate soil particles. In the first case, the soil remaining solid the connection between the surface and the lower layers of soil is readily made, while in the second the loose mass of soil particles prevents a ready connection, considerable time must elapse before the capillary tubes join the surface with the lower layers. Naturally, the moisture contained in the soil turned by the plow will be liable to escape more rapidly than before, because the freshly turned surface is immediately presented to those natural agencies, namely, air and warmth, which are potent in drawing out and carrying it away. Nevertheless, the great reservoirs lying underneath are proof against these forces, in proportion as they are protected by the completeness or incompleteness of the soil mulch made in the process of plowing.

The Effect of Tillage.

In the next place, the moisture in the surface soil may be very largely retained if shortly after the plowing is done the cultivator and harrow are used to make still more fine the particles of earth thrown up by the plow, thus retaining in part that which would escape if the tillage were not practiced. Tillage, to conserve moisture, while confined to the cultivated crops, as corn and potatoes, does exert an influence also upon these crops, which by virtue of their character cannot be cultivated, as hay, wheat, etc., as well as upon the others, because previous tillage, viz: harrowing, plowing, etc., are operations which result in breaking up the particles of soil and thus making the surface soil itself a place where water will penetrate more readily and freely, as well as enabling the roots to ramify freely in every direction, and giving them a larger surface area from which to draw their moisture in times of drouth or in frequent rains. It is apparent, therefore, that tillage exerts an influence in conserving the moisture, not only for the immediate crop, but for future crops as well, because improving the soil in such a way as to make it more absorptive and retentive of the water which falls a considerable time previous to the planting of the crop.

The Object of Drainage.

In the next place, drainage is an important operation in improving the absorptive and retentive power of soils for water. A common idea is that drainage by lowering the water-table is only intended to remove the moisture that is present in too great amounts and that it does not exert any influence in providing moisture for crops during a period of insufficient rainfall. This idea is in part erroneous, for the very fact that the water-table is lowered enables a more rapid percolation of the water of the rains in every direction in the soil, than if the drains were not there, and as the water percolates and is absorbed more fully, the crops that follow have a larger area of moist surface to draw their water from than if the surface area of the soil through which the roots can penetrate was limited. Besides, the lowering of the water-table has a very important influence in improving the absorptive property of soils by virtue of the fact that it enables the penetration of the air to greater depths, which changes its physical and mechanical character, making heavy soils, particularly, more open and porous.

The Advantages of a Mulch.

Another method which is only practicable for small areas, is the use of a mulch, which may consist of any loose material spread over

the soil and which acts as a blanket to prevent the rapid escape of moisture into the atmosphere. The principles involved in this case are quite similar to those described in the case of tillage and plowing. The water is prevented from escaping because the mulch distributed upon the surface soil prevents the immediate contact with it of the hot, dry winds; these affect first and directly the mulch itself, which protects and cools the surface. The use of mulches for small areas is very helpful, and while not practicable on large areas it can be made of practical value in gardens and orchards and for special purposes.

Growing crops are regarded as of use, also, in conserving moisture, though in a different way, particularly in the humid climates, since a soil well covered with a crop will absorb proportionately more of the rainfall than one lying bare, largely because it prevents surface drainage. Furthermore, the rapid escape of the water in the atmosphere is prevented because, as in the case of the other forms, the winds do not come in immediate contact with the soil, thus more of the moisture passes off through the crop rather than directly into the atmosphere. In the case of crop mulches grown as a catch for the primary purpose of covering the soil between the regular crops of the rotation there is a further advantage in that the vegetable matter accumulated by them is incorporated with the soil, which is materially improved because of the introduction into it of a substance which in itself, as already pointed out, has a higher absorptive power. This vegetable matter as it decays becomes what is known as "humis," a substance which exercises a very important influence upon the productive power of the soil.

Burning Straw a Wasteful Practice.

In many sections of our country, particularly in those States which possess soils rich in fertility elements, it is the custom to burn straw and other refuse vegetable matter. This is a bad practice, for even if it is not needed for improving the productive power of the soil in respect to other elements, if it is used as a mulch and incorporated with the soil it would assist very materially in retaining moisture for crops during the period of insufficient rainfall. If the straw is not needed for bedding and other purposes it should be distributed over the land, serving first as a mulch and then incorporated with the soil, thus improving its absorptive and retentive power.

The Effect of the Rolling.

Rolling the soil is another means by which moisture may be conserved, though the results of the use of this tool should be

understood. Its best use is in the preparation of the soil for seeding by mashing lumps and clods, in solidifying it and making it fine and friable. If used after seeding, it compacts the soil and leaves the surface smooth, thus providing the very best conditions for the rapid movement of air over the surface and, therefore, causing the ready abstraction of the moisture from it. It should not be freely used on heavy clay soils that are often already sufficiently finely divided and which are liable to become too much compacted, even under natural conditions, but rather upon open soils, those that are of a loose nature, as sandy and gravelly, in order that the particles may be pressed closer together, and thus to prevent the rapid escape of the water. Nevertheless, in dry seasons the roller is useful at time of seeding, because the compacted surface and the greater evaporation therefrom cause a rapid drawing up of the water from the lower layers to the surface of the soil, enabling a quicker germination and a more rapid early growth. In other words, the rolling tends to draw the moisture from the lower layers to the surface layer, and its use can be recommended after seeding under the conditions named. The roller should be used during the preparation of the soil, and if used after seeding the surface should be again stirred by a harrow, which makes a light soil mulch, or after it has performed its function in making fine and friable the seed-bed.

In order to guide the farmer in respect to the application of the general principles here laid down, the following general suggestions are made.

When to Plow.

It has already been pointed out that plowing aids in the conservation of soil moisture. The question that naturally arises first, is what time shall plowing be performed in order to obtain the best results. It is obvious that for certain crops, as winter wheat or fall seeding of any sort plowing must be done in summer or early autumn, unless the land is fallowed, whereas for spring planted crops, as Indian corn, spring wheat, oats, barley and a number of others, it does not necessarily follow that plowing shall be done in the spring; fall plowing for these presents many advantages, though there are also disadvantages, and these must be carefully weighed before the practice is adopted. For example, the ideal condition of soil during winter is to have it occupied by a growing crop, because in this condition it readily absorbs and holds the moisture and prevents, in large measure, losses that occur through drainage from it of the soluble plant-food constituents, still the effect of freezing and thawing, and of oxidation, which take place when land

is plowed in the fall, oftentimes results in a greater increase in immediate fertility than is accomplished by allowing the soil to remain in sod during the winter.

Soils Suffer Loss of Water When Bare.

In the case of lands that are not plowed in the fall, but which are allowed to lie bare during the fall and winter, they become hard and compact, particularly clay soils, and the rainfall is not absorbed but is lost, because of the rapid surface drainage. Hence, on account of the loss in the drains and streams, the season's rainfall, which with care might furnish sufficient moisture for a maximum production, is deficient and the crops suffer.

Fall plowing, by opening up and making more porous the surface soil, permits the ready penetration of water into it, as well as its percolation into the lower layers or subsoil, where it is held for the summer crop. In fall plowing no attempt should be made to thoroughly fine the surface, or to make it smooth, for this will encourage the soil to run together, or compact, particularly those of a clayey nature. Of course, this fall plowing applies more particularly to soils of a heavy character, or those which are compact or stubborn, rather than soils of good physical character. Fall plowing on sandy soils would not be of any particular advantage, as they do not compact, and rains penetrate readily during any season when land is not frozen.

If fall plowing cannot be accomplished, then the plowing should be done in early spring, in order that the capillary connection between the disturbed surface soil and the lower layers may be established before the spring rains cease, this, followed by deep cultivation and thorough pulverization of the surface previous to planting contribute materially to the conservation of moisture.

Deep plowing also contributes to the absorptive power of soils, and conservation of moisture, because providing for a much larger area of soil for the penetration of the roots, and if practiced in the fall, the best time to increase the depth, the inert material thrown up weathers during the winter, and the resulting chemical changes also improve the physical character, as well as increasing the active fertility of the soil. If the plowing is left until the late spring, then deep plowing is not so advantageous for many crops, as shallow plowing, for if there is sufficient rainfall in the early season the surface soil is soon dried and the roots of the young plants have not had time to penetrate deeply enough to take advantage of the reservoir of moisture lying underneath, whereas, if the plowing is shallow the roots soon reach through into the solid bed below, which contains the moisture, and the plant is enabled to resist more effectually any drouth which may follow.

Cultivation After Planting.

In order to retain the moisture after the crop has been planted, cultivation should be deep, early, and gradually lessened as the season advances, in order that in the early season the rainfall may penetrate to the lower layers, and in the later season the mulch provided by the cultivation may not be so deep as to enable the complete drying of the surface soil. The advantages of continuous cultivation are also marked, inasmuch as every time the soil is stirred the connection between the lower layers and the surface is broken and the water below must seek new outlets for escape; and until these are obtained the water is retained for the use of the plant.

The method of cultivation also should be observed. On soils naturally well drained, cultivation in ridges contributes to the loss rather than the conservation of moisture, as the ridges lying so much above the main surface of the soil dries out more rapidly than if level cultivation is practiced. Naturally, in wet climates it is frequently advantageous to ridge the soil, in order to provide for the rapid drainage of the water, but in soils where the need is for water rather than for lack of water, ridge culture is not advantageous.

Frequent tillage, or continuous cultivation, also tends to increase fertility, by causing a more rapid change of the insoluble constituents into soluble forms. The constant stirring of the soil brings new particles into contact with sun and air. In soils rich in dormant or locked-up food, this method of improvement, which results in increasing their direct fertility is strongly commended, since it can be accomplished without any outlay of cash and by the regular labor of the farm.

Further Methods of Improvement.

Soils may be further improved, namely, in two directions, first, by saving in the soil for the use of the plants those constituents which by improvident and irrational methods of practice are likely to be lost; and second, by adding to the soil such amendments as may increase the activity of the constituents already there, or which may contain such substances as are essential for the growth of plants.

Losses Due to Methods of Practice.

One of the means whereby soils may become impoverished, or at least be reduced in productivity, is through the losses that occur from improvident methods. For example, it has been demonstrated that plants obtain their food in a soluble form, and unless it is taken up when it has become soluble there is danger of its being

carried away in the rains that pass through it. A saving, therefore, may be effected by keeping the land constantly occupied with growing crops, in order that food which is made available may be absorbed by the roots of plants and converted into organic forms which by their decay render it serviceable to other crops. The methods of practice quite common in the East require that the land lie bare at certain seasons of the year and some times for long periods, during which severe losses of plant food may occur, the chief element of which is the expensive constituent, nitrogen.

Experiments conducted by Sir John B. Lawes, at Rothamsted, England, showed that land in good condition, left bare from early fall until spring, would lose an equivalent of 37 pounds of nitrogen per acre. It was also shown that this could have been held and appropriated by crops. This loss of nitrogen may not seem a great matter at first glance, but a study of the losses in relation to crop production shows that it is really very serious. In the first place, this loss of nitrogen, which is possible and probable on good soils left bare, is more than equivalent to the amount contained in the average yield of wheat, rye, oats, corn or buckwheat; besides the nitrogen which is carried away by the drainage water, is in the very best form for feeding the plant, or it would not have been lost, and thus its absence leaves the soil not only poorer in this constituent element, but poorer in the sense that the remainder of it in the soil is in a less useful form. While the amount and time of rainfall cannot be controlled, its effect upon the soils in causing loss may be largely governed if proper attention is given to the matter of growing catch crops, in order that the land may be constantly occupied.

Another source of natural loss of nitrogen, is its escape as gas into the atmosphere, due to the oxidation of vegetable matter, which takes place very rapidly when soils rich in this substance are improperly managed. In the system of continuous cropping which is observed in certain sections of our country, the annual losses of nitrogen are much greater than the amounts carried off in crops, and while continuous cropping is not so generally practiced in the East the losses that occur, because of improper methods of rotation, which leave the land bare for any length of time, are very considerable. Indirect losses may occur, too, because the conditions are made unfavorable for the activities that are present in the soil. Take, for example, the rotation which allows the land to remain bare from the early part of July until September, when the rotation of corn, oats, wheat and grass is practiced. After the oat crop is removed in July the land is frequently allowed to lie uncovered, particularly in dry seasons, for a month or six weeks, during which

time the weather is often very dry, usually very hot; the temperature of the soil is raised to the point which reduces the activity, if not destroying altogether the soil organisms, and because of the absence of these the changes that take place later are very materially reduced. Rotations should be adopted which will permit the continuous covering of the soil by regular crops, or such catch crops as will keep the land covered between the seeding of the different ones in the rotation. A discussion of the crops adapted for this purpose will be found in subsequent pages.

There are also losses of mineral elements, which may be prevented by keeping the ground covered by the growing crops. For example, lands that lie bare during the late fall, winter and spring are liable to be washed and gulleyed, and the finer particles on the surface carried either away from the land or to such points as to make it impossible to utilize them in the growth of crops. This loss may be avoided if the above suggestions are followed.

Improvement Due to Soil Amendments.

Another method of improvement, which is partly chemical and partly physical in its character, is the addition of lime. This can hardly be regarded as a natural method of improvement, because additions have been made to the soil of substances not before present; still it differs from the addition of manures or fertilizers, which contain the essential fertility constituents, nitrogen, phosphoric acid and potash, as the improvement is due, not so much to the direct action of the substances added as to their effect upon the substances already in the soil. That is, the function of the lime is to increase the active fertility of the soil by action upon the substances there, and thus causing a greater absorption by the plant of the nitrogen, phosphoric acid and potash already in the soil, and without adding thereto that which was not there before. The three main ways that lime may improve soils are: First, *by attacking the vegetable matter*, thus assisting in the change of the combined nitrogen into active, and by the reaction of the lime with certain phosphate and potash compounds, rendering them available to plants. This function of lime, however, is only largely valuable on soils already rich in vegetable matter and mineral constituents.

The second function of lime *is to change the physical character of the soil;* for example, on heavy clay soil, whose particles are finely divided, and whose texture is so dense and compact as to prevent the easy penetration and movement of water, the lime helps to coagulate the fine particles of the soil, thus making it more open and porous, and permitting the penetration and free circulation of air and water. While upon the sandy soils, which are too loose and open and texture, and which permits a too free movement of water,

the effect of the lime is to cement the particles together and make the soil more compact, which increases its absorptive properties and a consequently greater retention in and utilization of the food in the soil by the plant.

The third function of lime, *is to neutralize any acid* that may be present in the soil, and which not only injuriously affects the growth of certain kinds of plants, but which is destructive to the life and growth of many of the lower organisms. Naturally this function of lime will be exerted whenever the lime is used for the other purposes mentioned, still there are cases where it would be desirable to use it only for this purpose, in which case the application may be much less. The advantage of lime in the growth of leguminous crops, for example, is not altogether because of the fact that this class of plants requires an abundance of lime, but because the lime exercises a favorable influence upon the physical character of a soil, besides making it neutral, and thus a better medium for the growth and development of the soil organisms, which have the power of gathering nitrogen from the air and which cannot thrive without air or in an acid medium.

The Importance of Vegetable Matter.

The lines of practice which have been suggested, in order both to prevent losses from soils and to improve their physical character, namely, the continuous cropping system, which holds fast to the available food in the soil, liable to be lost when the land is uncropped, and the addition of amendments which assist in making the necessary changes, also includes the further advantage of adding to the soil that which it did not before possess, viz: vegetable matter, or humus-forming material, which also improves the soil, not only in its absorptive properties for both moisture and plant food, but which contributes to the store of active essential constituents. The various crops that may be used to attain the first mentioned purpose, however, do not possess an equal value in this respect, and unless the principles which govern and the conditions under which they are grown, as well as the influence of the crops grown upon future productivity are well known the results obtained may not be always satisfactory.

Kind of Crops to Grow.

In the first place, the crops that may be used are divided into two distinct groups, in one group are included those plants which can obtain the necessary nitrogen for their growth only from soil sources and called "nitrogen consumers," and, therefore, when plowed down do not add to the soil any essential constituent element and are only

serviceable in improving the physical character and absorptive properties of soils. The members of this group include the cereal grains, the grasses, buckwheat, turnips, rape, etc., yet, because of their time of growth and period of rapid development, it is often desirable to grow crops of this class, particularly where the primary purpose is to prevent losses of plant food rather than to rapidly build up the soil in nitrogenous organic substances.

The second group of crops includes those plants which belong to the legume or clover family, and which do not depend solely upon soil sources for their nitrogen, but can obtain it from the air, these in their growth and removal from the soil need not materially reduce the content of soil nitrogen, but rather particularly when plowed down directly add to the crop-producing capacity of soils by improving their physical character and by increasing their store of nitrogen. In order that a plant of this group may obtain its nitrogen from the air, however, the soil must contain originally, or must be inoculated with a specific organism, the presence of which in the soil is manifested by the growth of nodules upon their roots and through which it is believed the plants obtain their nitrogen, though the exact process is not yet fully understood.

Advantage of Legumes.

The use of this class of plants, therefore, possesses a three-fold value in the improvement of soils, first, in absorbing and retaining the soluble food in the soil; second, in providing vegetable matter, or humus-forming material, which contributes to the physical improvement of soils; and third, by adding to the store of nitrogen in the soil, the element most likely to be deficient, and which can be used by plants whose sole source of nitrogen is the soil. Fortunately, because of the number of plants belonging to this group, and because of their wide range of adaptation to the various conditions, it is possible to introduce one or more of them into the regular system of farm practice, without interfering with useful and profitable rotations. Many of them, for example, the various clovers, red, crimson and alsike, are already grown extensively, and their value in the rotation well understood by practical men. There are many others, however, whose characteristics have not been carefully studied until recent years, and whose usefulness are just beginning to be appreciated. Among these are the Canada field pea, the soy bean, the cow pea and the various varieties of vetch, all possessing that valuable power of appropriating for their use the free nitrogen of the air, and thus contributing directly to the potential fertility of the soil. The plants of this group are often called, and properly, "nitrogen gathering" crops, and their renovat-

ing and improving character are seldom over-estimated. A brief discussion of the various plants suitable as renovating crops, together with their characteristics and relative advantages must naturally precede specific directions as to their use.

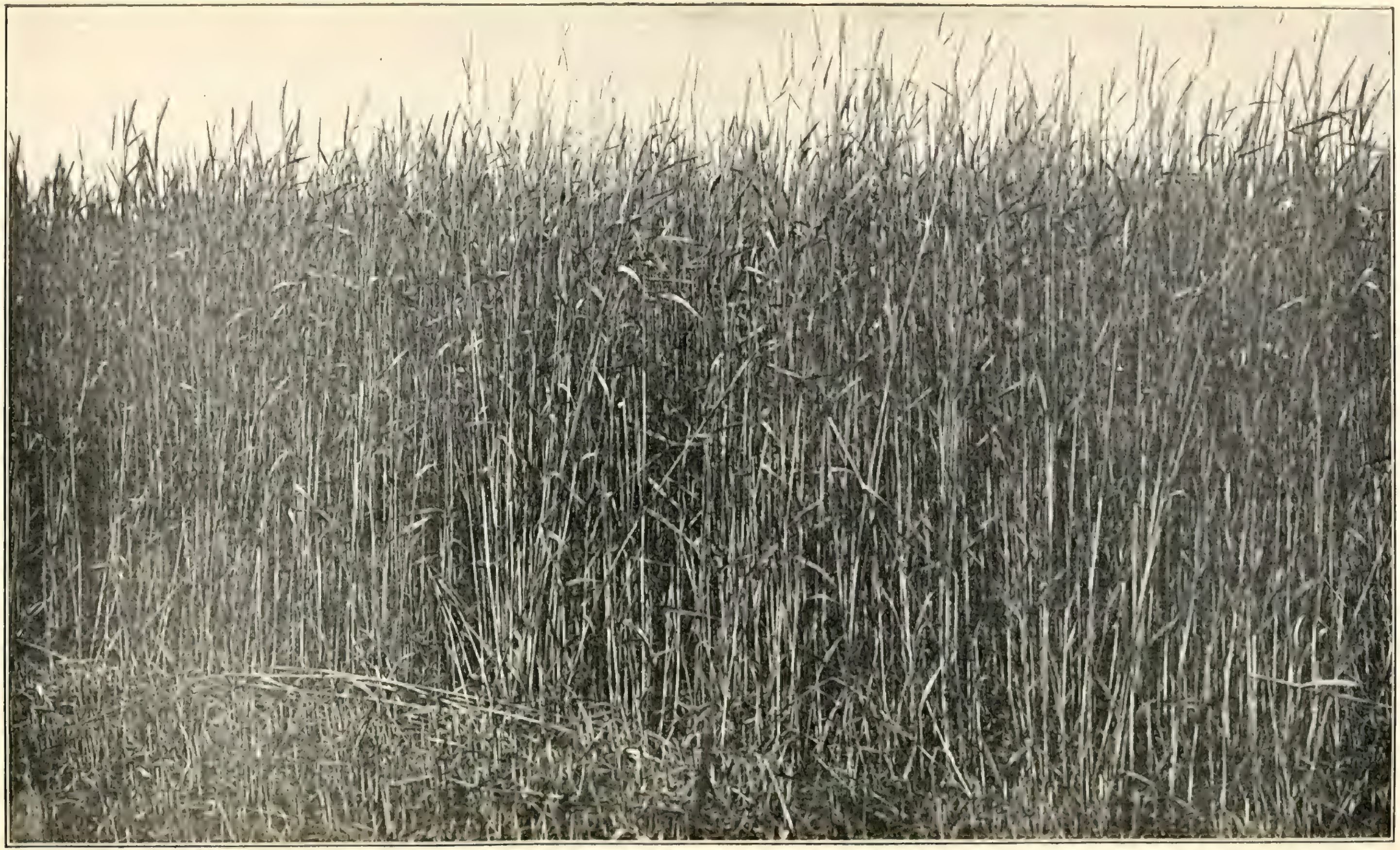
Catch Crops, "Nitrogen Consumers."

The crop more generally used, primarily, to prevent losses during late fall and winter, is rye. The advantages of this crop for this purpose are that it may be seeded late in the year, after other crops have been harvested, grows rapidly, withstands the winter well, is a good forager, makes a rapid early growth, which may be plowed down for early crops as corn, potatoes, tomatoes, etc. Furthermore, the cost of seeding is small, and farmers are familiar with the handling of the crop. Its chief value, however, lies in its hardiness, withstanding well severe weather, and its habit of late fall and early spring growth, which holds the soil and prevents washing and mechanical losses; it readily absorbs the available food present in the soil, and even when plowed down early contributes in some degree to the humus-forming substances in the soil, and thus improves its absorptive properties.

Wheat possesses the characteristics which have been mentioned for rye, though not in the same degree. The seed usually costs more, and satisfactory growth requires a better preparation and fertilization of soil than for rye; besides, the plant is not so hardy and starts later in the spring. It is, therefore, as a rule, less satisfactory for the purpose than rye.

Buckwheat is another plant of this order, which has been used very largely as a soil improver, particularly in the breaking up of new lands, and for this purpose is a useful plant. Its season of growth is during the summer months of July and August, when conditions are usually favorable for the progress of those activities which cause changes in the soil substances, hence is able to make a relatively large growth on medium poor land; when grown as a renovating crop it improves the physical character of soils by keeping the soil covered during the hot season and by adding vegetable matter.

Certain varieties of the mustard plant are extensively used as a summer catch or fallow crop in other countries, particularly Germany; the plant grows rapidly and is able to subsist on rather poor soils, thus accumulating in the surface soil materials more readily appropriated by other plants. It, however, does not present any peculiar advantages for American conditions not possessed by the more familiar crops grown here.



RYE.

The turnip also possesses characteristics of value, owing to its rapid appropriation of food in cool weather and consequent large growth during the late fall. These varieties which root deeply are preferable, because they gather a portion of their food from lower layers of soil and store it in their enlarged bulbous roots, near the surface; besides this peculiarity, the growth of the crop is an important factor, as it exerts a favorable influence upon the physical character of the soil. It causes a separation of the soil particles and permits a freer access of air. The disadvantages of the crop is that it dies at the beginning of winter. Still, if a considerable crop is grown, the mulch, consisting of roots and leaves, will hold the soil together, besides preventing as rapid a leaching as if the soil were entirely exposed.

Dwarf Essex rape is another plant that may be grown as a cover in the late fall and to serve as a mulch during the winter, and for these objects serves an admirable purpose, though possessing the disadvantages mentioned for the turnip.

All of the crops here mentioned may be made virtually catch crops and thus not interfering with a regular rotation, and even if pastured or completely removed they leave the soil in a better condition than if no crop had been grown; the soil is improved, because its functions have been exercised and at a minimum expense.

Catch Crops, "Nitrogen Gatherers."

Of the "nitrogen gatherers," the clovers as a class are perhaps the best known, though it is believed that a brief description of the characteristics of the various useful plants belonging to this group will be helpful.

Red Clover.

The renovating character of a crop of red clover is well known, and even when only the stubble and roots are the source of the additions made to the soil, the improvement which follows is very marked. Farmers know that corn or wheat seeded on a clover sod will do much better than when seeded on raw ground or on sod from grasses. It is ordinarily a biennial though sometimes the life will continue through three seasons. Its characteristics are such as to make it adapted to a wide range of soils and of climatic conditions, though it thrives best on good soils, well supplied with humus. It is liable to be uprooted on wet soils by the alternate freezing and thawing in spring, and to be destroyed by hot weather on light sandy soils. The amount of seed to be used when the purpose is to secure the largest crop of clover is about 12 to 16 pounds per acre, depending on the character of the soil, the better the soil the less the amount of seed required.

The ameliorating influence of this crop upon soils is due primarily to two causes, first, to the extensive root system, which is distributed widely throughout the soil, and to great depths in it, thus changing to some extent its physical character, as well as the storing up of food in a large tap-root near the surface of the soil, in organic forms, which readily decay; and second, because the plant is a "nitrogen gatherer," the crops of clover removed do not exhaust the soil of nitrogen, but rather add to its store, hence the succeeding crops have at their disposal a larger amount of this element than if they were preceded by the grasses or cereals, which are "nitrogen consumers." The wider and more frequent use of red clover can be commended from all standpoints, where the increase in and the maintenance of natural fertility are important, and in general farming these points are always important.

Mammoth clover is a near relative of the red variety and resembles it closely. It is a coarser plant and a greater forager; where clover is grown solely for use as a green manure the Mammoth may often be substituted with advantage for the red. It is also better adapted for wet lands than the red. The amount of seed used may be the same as for red clover.

Alsike Clover.

Alsike clover is believed to be a cross between the red and white clovers. It has a semi-creeping habit like the white variety and only does well when seeded with a variety making a more upright growth, as the red or Mammoth. The mixture is desirable, since the alsike is better adapted for cold, moist soils and is also hardier than the others, withstanding winters that kill the red and Mammoth varieties. A good practice in growing these varieties of clover with the cereals is to sow early in spring on the wheat or rye, seeded in the fall, and at which time timothy has been seeded, at the rate of 8 to 10 pounds per acre; the usual mixture of alsike and red is two pounds of the former to eight of the latter, using about eight pounds per acre. The seed of the alsike is so much smaller than the red that seeding in these proportions results in a very even mixture of the clovers. The seeding may, however, be made with advantage during the summer and early fall, without cover crop, either for turning under in spring as green manure or for hay or pasture. Such seeding should be made on soil well prepared and the seed lightly covered.

Crimson Clover.

Crimson clover is an annual, and because of its useful characteristics has made a place for itself in American agricultural practice.

CRIMSON CLOVER.

Its habits of growth are not so well known as those of the other varieties described and for this reason, among others, is not so generally distributed even in those sections where it thrives well. Its habits are such as to make it undesirable to substitute it for the red, though it may well supplement it, and thus add another useful clover crop to our list. It is essentially a cool weather plant, thriving well in late fall and eary spring, and maturing seed in the middle States about June 1st. These characteristics of growth make it especially suitable for a catch crop, which may be used without interfering with regular rotations. It has proved hardy in the eastern and middle States, though many failures are reported, which are probably due in large part to the failure to observe in its seeding the peculiar habits and characteristics of the plant. The impression that because it is a catch crop it will grow well on poor soils with other crops, under all conditions of season and climate and without particular care in seeding, is erroneous. Like other plants, crimson clover must have food—it is affected by drouth and cold and severe weather; it cannot subsist with other crops, which rob it of moisture and plant food, and it must be carefully seeded, in order to insure against adverse conditions, though when conditions are favorable it will catch and grow from a simple sowing of the seed on raw ground. It should preferably be seeded at the rate of 12 to 15 pounds per acre, on a well prepared seed-bed and covered lightly with harrow or weeder. It is not suited for spring seeding, as it ceases to grow as soon as hot weather comes, the best period for seeding ranges in the eastern and middle States from July 15th to September 1st; it may, therefore, be used as a catch crop, seeded in corn, berry patches, orchards, etc., after the regular cultivation has ceased for the season and after early potatoes, tomatoes and other crops harvested early enough in the season to enable its roots to get a hold of the soil and to make considerable top before cold weather sets in. While it requires a good soil for its best development it is well adapted for light sandy soils if well supplied with mineral food. It will grow later in the fall than red clover, because not injured by frost, and also make a more rapid spring growth than any of the other clovers seeded in the late summer. Where the land is light and poor, a dressing of acid phosphate, say at the rate of 150 pounds per acre, will materially aid in securing a catch and insuring a crop. Its early maturity is one of its most valuable characteristics from the standpoint of its use as green manure, making it possible when seeded in corn, for example, to secure a considerable green manure crop, in time to plow down for another corn crop. When the plants are largely destroyed because of severe winters, the accumulated nitrogen and organic matter in the

fall is sufficient to amply repay the cost of seed and seeding. Studies made at the New Jersey Experiment Station show that a good thick crop, six inches high, will contain nitrogen and organic matter equivalent to that contained in five tons of yard manure; that the nitrogen is quite as useful for the corn plant as that contained in the manure, besides it is evenly distributed and there is no labor involved in its application. Another advantage of the crimson clover is that it is a spring green manure crop, thus permitting a return from it in the same season in which it is used. It will pay farmers to carefully study the habits of this plant and then to introduce it in their rotations as a soil renovator. If failures occur the cause should be learned and a remedy sought; discouragement should not follow one or two failures; remember that red clover sometimes fails. It has succeeded in many instances when red clover has failed.

Other Varieties of Clover Sometimes Used.

There are various other varieties of clover which possess useful characteristics, though with the possible exception of sweet clover, which is sometimes used in the south, they do not possess advantages superior to those varieties already mentioned. The sweet clover (*Melilotus Alba*), is a rank growing plant and is quite common as a weed along roadsides and in waste places. It is seldom cultivated, either for forage or green manure, though it seems to have the power of acquiring food from sources inaccessible to other plants of the same family. It thrives particularly well on soils rich in lime. Experiments with it in Alabama, Mississippi and Ohio show that it in common with other legumes aids in soil improvement. Its use is recommended only where other varieties do not meet the requirements.

Alfalfa.

Alfalfa belongs to the clover family and while one of the most valuable of this class of plants, from the forage standpoint, is not adapted for use as a green manure, because of the difficulty of securing a stand, and because of its comparatively slow early growth. It is a perennial, which does not reach its maximum annual growth until the second or third year after seeding.

The Field Pea.

The field pea, the variety that is used for forage, for cover crop or for green manuring, is usually known as the Canada field pea, though the name includes a number of varieties, as the Golden Vine, Prussian Blue, Green Field, Mummy, etc., any one of which is satisfac-

COW PEAS.

tory for the different purposes. This field pea does not differ in appearance nor characteristics from the ordinary garden pea. It thrives well in the more northern States, only in the cool moist weather of early spring and late fall, and for this reason is not adapted to sections south of the middle States, and its use as a cover crop, or for green manure is limited for this reason, as well as to the fact that it does not grow well except on good soils. Still, there are occasions when its use will meet conditions not provided for so well by other plants. For example, it may be seeded in September, or even early October, periods too late for the seeding of other legumes, and because of its rapid growth makes a crop before freezing weather; the crop serving as a mulch during the winter, preventing the wasting of sandy soils due to high winds, and the accumulated nitrogen and organic matter provide readily available plant food for spring sown crops. It has proved of great advantage in many lines of farming, where the crops are not removed early enough to permit the seeding of crimson clover, or other leguminous crop. It should be seeded at the earliest possible time in spring, and in fall, not earlier than September 1st, at the rate of one-half to two bushels per acre, and the seed well covered, preferably two to four inches.

Cow Peas.

The cow pea is probably neither a pea or a bean, as it differs widely from both, still it belongs to the same family, as do the clovers and field peas. Its origin is authoritatively stated to be the east, where it has been cultivated for thousands of years; it is believed to have been introduced into this country in the early part of the eighteenth century. Its best development is found in warm climates, hence in this country it has found a congenial home in the southern States, where it reaches its maximum development. A large number of varieties have, however, been developed which are adapted to cooler conditions, so that now it is well distributed even throughout the north, where it is proving itself one of the best annuals, and its adaptation to various uses and the rapid and large development of plant, make it one of the most useful of the legumes for soil improvement.

Varieties.

The natural tendency of the plant toward variation has resulted in a large number of varieties, though the permanent and distinct ones are comparatively few; the same variety is given a different name in different parts of the country, as, for example, one variety goes under the name of Unknown, Wonderful and Quadroon. In addition to the confusion arising from this practice. The selection of a variety is still further complicated by giving the same name to

a number of varieties, as, for example, the name of Crowder is applied to any variety in which the seeds are closely packed together or crowded. The further fact that the season and climate exert such an influence upon the plant as to make a variety in one place very different in its character than in another, makes it difficult to give positive advice as to the selection of varieties for specific purposes. The different varieties range in form from a bush a foot or so high, without runners, to those possessing vining or trailing habits, the vines reaching a length of from ten to twenty feet long, according to soil and season. The pods also range from four to eighteen inches in length, giving seed of every possible shape and form. The period of mature growth also varies, as do the habits of growth. The different varieties ranging in their time of maturity from two to six months, though the habit of growth does bear some relation as to the time required; the smaller the plant and the more nearly it approaches the bush form the shorter the time required for maturity, while the more rapid the growth and the larger and longer the vines the longer the time required. In order to select the proper variety for the various purposes, the object of its growth should be clearly understood. Where short, quick growth and maturity are required then, particularly in the north, the bush variety should be selected; whereas, if the purpose is for forage, and the period of growth can be extended, then the vining varieties are likely to be more useful.

In cases where they are grown primarily for green manures, then the time during which they grow should determine the variety to select. It is more difficult to select varieties for the north than for the south, as the plant has not been so carefully studied in this section. Nevertheless, the Early Black, Whippoorwill, Wonderful and Clay varieties have proved excellent for the various purposes. The Early Black, where the seed crop is desired, as it grows and matures quickly, whereas the others are better adapted for forage and green manure, as the longer they grow the larger the crop of succulent forage in one case, and of total crop in the other, except in the case of green manures, when only two or three months can be given to the growth of the crop.

Method and Time of Sowing.

The time of seeding the cow pea will depend upon the character of the weather; they should not be seeded in spring until danger of frost is past and the soil is thoroughly warm. In cold, backward springs many failures have been recorded, because of too early seeding; the seed are liable to rot in cold weather, and if germination takes place the plant is retarded in growth in cool weather and the crop is unsatisfactory even if

warm weather follows. This is of particular importance where they are seeded for forage or hay, as very often crops are failures because the seeding was so early as to cause the weather to injure the plant, and thus prevent its early growth. Neither should they be seeded later than two months before the average date of frost, as the first heavy frost will destroy the young plants and no variety that is now known will reach a satisfactory stage of growth for any purpose inside of this period. For forage and for green manure the crop may be sown broadcast at the rate of from one to one and one-half bushels per acre, or may be drilled in with an ordinary grain drill. If the seeding is not made too early, broadcast methods are very satisfactory. If, however, the early growth of the plant is retarded then weeds obtain a foothold and it is likely to be choked out.

Where the object of growing the crop is for seed, then planting should be preferably in drills, from two to three feet apart, or a little closer than for corn, and the amount of seed may be reduced to three pecks per acre. Seed should be covered from one to two inches deep and on very light soils a little deeper. The season to some extent governs the depth at which seed should be planted—in a dry season the deeper the seed the better. The difficulty in late summer seeding is that crab-grass is liable to choke out the plants.

There is perhaps no other crop that is so generally useful for soil improvement as the cow pea. In the first place it grows during the hot summer, when it is desirable to have the ground covered and its long tap-root penetrates into the subsoil, loosening it and making it more porous; and in the second place, the absorption and assimilation of the free nitrogen in the air by this crop, which is characteristic of all the legumes, makes it one of great service, even when the crop is used for forage and only the roots and stubble are left as additions to the soil.

In using the cow pea it may be plowed under while green, or may be left on the surface as a mulch during the winter, and plowed under in the spring. It may be partially grazed and the stubble and roots plowed under, and in any case the improvement of the soil is very marked. Where the forage can be used to advantage and the object is to gradually improve the soil, then the better plan is to remove it either for use as green forage or for hay, as on good soils the stubble and roots left will furnish sufficient nitrogen to supply the early needs of a cereal crop. On light soils it is also desirable to remove part of the growth, as the turning under of a too heavy crop of cow peas would be likely to injure rather than to improve the physical character of the soil. The danger from plowing under heavy crops of green manure is not so marked in the north as

in the south, where the temperature range is high for a longer period. On heavy clay soils the improvement in plowing under heavy crops is very marked.

Soy Bean.

The soy bean has a strong central root, stiff stems, broad leaves and somewhat resembles the ordinary bean, though it is larger and bushier in form. The plants may be dwarf and early maturing, or late and tall, though in no case do they vine as do the vining and trailing varieties of cow peas. There are a number of varieties—the Green seems to be the variety most generally used and the crop from it varies according to the season and climate. This plant resembles the cow pea in many of its characteristics, namely, that it should not be seeded until the soil is warm, and where grown for forage it should be preferably planted in rows, in order that it may be cultivated. For green manuring purposes it may be seeded broadcast. The amount of seed per acre will vary from one to one and one-half bushels when broadcast, depending upon how well the seed are covered; when seeded in rows the amount of seed may be reduced to one-half bushel, or three pecks, per acre. The land should be put in good condition, in order that germination may be prompt. It does not possess, for green manure purposes, any characteristics different from those mentioned for cow peas. In fact, experience thus far shows that the soy bean is slightly more difficult to handle, and the yields are not so heavy, though the plant contains more nitrogen in the dry matter than the cow pea. It has been grown for green manure purposes when there has been a scarcity of the seed of the cow pea, and many prefer it to the cow pea, because it is easier to completely cover the plant in plowing, whereas a large crop of cow peas is particularly difficult to plow under. The decay of the plant will probably be quite as rapid as the cow pea, and hence serve quite as well as a source of nitrogen to the cereals.

Velvet Bean.

The velvet bean has attracted a great deal of attention lately in the southern States. It originated in the tropics, and has proved successful only in the southern States. In Florida it has been one of the most useful of the forage plants and is highly regarded as a green manure crop. It grows well on light, sandy soil and the yield is ordinarily about the same as for the cow pea. The season of growth is much longer, and for that reason the seed cannot be matured except in the south. The results of experiments conducted in the middle and eastern States show that it is not well adapted for these sections, and does not make as satisfactory a crop for any purpose as the cow pea.

SOY BEANS.

Sand, or Winter Vetch.

This vetch is an annual, and is a native of western Asia. It has been recently grown wih success in the middle, eastern and southern States. It is a trailing plant, thus making it difficult to harvest for forage, unless seeded with some small grain, as wheat, oats or rye, to serve as a support. It may be planted either in spring or fall, at the rate of about one and one-half to two bushels per acre. It grows much better upon light, poor soils than cow peas or soy beans, and for such conditions is much superior as a green manure crop. The cost of seed thus far has practically prohibited its use, except in cases where small areas are grown.

Soil Inoculation.

The superior advantages of the leguminous crops as green manures, are due in large part to the fact, as already pointed out, that they are capable of obtaining their nitrogen in part, at least, from the air, a source inaccessible to the other class of plants. It must be remembered, however, that in order that this function may be exercised it is necessary that there shall be present in the soil certain organisms which attach themselves to the roots of the plants; their presence in the soil is indicated by the formation of tubercles or nodules on the roots, which range from a pin-head to a pea in size. Where these nodules are not present on the roots it is an indication that the proper organisms are not present and that the legumes, in common with other plants, must derive their nitrogen from the soil, and thus from the standpoint of accumulation of nitrogen they are, under these conditions, no more useful than the cereal crops.

Methods of Inoculation.

In view of these facts it becomes necessary in order to obtain the full benefit from the growth of the leguminous crops, to see to it that the proper organisms are present in the soil. This may be readily accomplished by inoculation, or introducing the specific organism into the soil. That is, soils in which these organisms are not present may be supplied with them by using a portion of the soil where they are present to introduce them. Experiments that have been conducted show that a small quantity only is necessary to accomplish the purpose, for example, a peck or one-half bushel of soil taken from different parts of a field which contains the organisms will, if sown broadcast over an acre which does not contain them, introduce the organisms, which multiply and distribute rapidly, and be prepared to do their work for the crop. Once

the organisms are present in the soil there is but little danger that they will be destroyed under good conditions of practice, and if the crops that are grown upon the area which has been inoculated are used as food for farm stock and the manure used elsewhere upon the farm the chances are that the organisms will be generally distributed, so that the work of inoculation is not a serious matter.

It very often happens that in the growing of such crops as cow peas and soy beans the first crop grown will not show the tubercles on the roots, but that the second one grown will be well supplied with them, indicating that the organisms are very often introduced into the soil by means of the seed, and seedsmen in some cases now make it a practice in harvesting their crops of soy beans and cow peas to pull them instead of cutting them, thus in threshing, mingling more or less of the soil which contains the proper organisms with the seed and which when removed leave the seed well inoculated.

The Amount of Nitrogen Gathered.

It does not follow, however, that even when these organisms are not present in the soil that all of the nitrogen contained in the crop of the legume grown has been gathered from the air, as it has been shown that the plants would preferably take soil nitrogen, and, therefore, that on good soils, well supplied with nitrogen, the proportionate amount of nitrogen drawn from the air will be much less than that will be the case when the crop is grown on soils poor in nitrogen. The exact amount of nitrogen gathered by a crop cannot, therefore, be exactly determined, though it is believed to depend upon the character of the soil, whether rich or poor in available nitrogen, hence the usefulness of the legumes as a means of acquiring nitrogen is greater when grown upon soils poor in this substance; these soils are, however, more greatly benefited by the accumulation than those previously rich in the element nitrogen.

The Importance of an Abundance of the Mineral Elements.

It has also been pretty clearly demonstrated that the proportion of nitrogen gathered by the plant from the air, particularly upon poor soils will depend upon the supply in the soil of the other necessary plant food ingredients. That is, soils poor in nitrogen and oftentimes poor in physical character if not well supplied with the minerals, phosphoric acid and potash, will not produce a large crop of cow peas or soy beans, or any other leguminous plant, because its grows and development depends upon the ease with which it may acquire the necessary amounts of the other elements of nutrition. Hence, in attempts to build up poor soils by means of green manure crops it is quite as necessary to fertilize with the minerals, in order

to insure maximum growth, as it would be in order to grow any other crop, the purpose of which is the crop itself, rather than for its effect in soil improvement. This is entirely reasonable, as the mineral constituents cannot be attained from any other source than the soil, and they are quite as essential in the complete growth and development of a crop as is the nitrogen.

The point is, that green manuring does not result in building up and making better a soil that is naturally poor in the mineral constituents. It can only contribute the nitrogen, and that in itself is not a complete food, it is only one of the essential, though very important elements. On heavier soils, overlying strong subsoils, as, for example, clay loams, and which are usually rich in dormant mineral constituents, the practice of growing the legumes may result in building up the soil, both in available nitrogen and in available minerals, as these plants have the power of acquiring the minerals from such soils more readily than certain other classes of plants, and thus by their growth there is an accumulation of nitrogen, as well as an accumulation of the mineral elements in a more available state, and the soil is improved in all directions without the direct addition of any fertilizing substance. The roots running deeply in the soil and subsoil gather the mineral food and store it in their larger roots near the surface, where it is not only available from the standpoint of other plants reaching it, but available from the standpoint of its being more readily acquired by them. Such soils may be improved and kept in a high state of fertility by the frequent growth of a renovating crop, whereas, on light soils which are poor in all constituents, the improvement will be in proportion to the amount of minerals supplied, as they will measure in a degree, at least, the rate of appropriation of the nitrogen. These considerations are practically true for all of the plants in the group of legumes that has been considered, though the different plants may apparently differ materially in their rapidity or degree of growth, even on the same soil and without the addition of other materials. The fact remains, however, that genuine improvement of poor soils cannot be expected from the growth and use of green manure crops alone.

The Plowing in of Green Manures.

Another point that should be clearly understood in the matter of soil improvement by means of green manures is the time for plowing down the crop. In the first place, the character of soil exerts an influence on this point. As a broad, general rule, there is danger of injury to light soils in plowing down a heavy burden of green material, particularly in warm weather, whereas upon heavy soils

the danger is very much less, and in fact ordinarily quite remote. Hence, in the discussion of the subject the influence of the season of growth of the plants is worthy of consideration. If the crop which is intended for green manure matures rather early in spring, then the time of plowing under must be governed by the purpose of the growth of the crop which follows, as its development will be materially influenced by the operation. Take, for example, rye, representing the class of "nitrogen consumers." This crop makes a rapid, early development, and if allowed to entirely mature it not only draws heavily upon the available food constituents of the surface soil, but rapidly and often completely exhausts it of moisture. Hence, if plowed down in its mature state it will result in leaving a mass of vegetable matter not readily decayed between the surface and the subsoil, thus cutting off absolutely the connection between the surface and the reservoir of water lying below. Should, therefore, dry weather follow, the decay will be very slow and the succeeding crop will have only the food and the moisture that are contained in the surface soil turned over, and from this the available food and the moisture have been largely extracted by the maturing of the large crop of rye.

Spring Green Manure Crops.

Hence, it is readily seen that the time of plowing down the green crop is a matter of the very greatest importance. Rye is an excellent green manure, if properly used. It should, therefore, be plowed down not later than when just coming into head, when the vegetable matter is immature, which readily breaks down and decays, and when the smaller growth of the plant has made but little demand upon the soil for moisture. Furthermore, in this early stage of growth the vegetable matter does not make so bulky a mass between the surface and subsoil, and thus the capillary connections between the upper and lower layers are readily made, and hence not preventing the next crop from securing its needed moisture.

The principles involved here are practically the same for crops of a leguminous character. For example, crimson clover, which has been seeded in corn, or that has been seeded in orchards for the purpose of accumulating nitrogen, also prevents mechanical losses and contributes to the improvement of the physical character of the soil. Still, the time of plowing down the crop is of the very greatest importance, not only in its influence upon the character of the soil itself, but upon the growth of the subsequent crop. Should the crop mature, and the weather conditions be entirely favorable, and there is sufficient moisture and warmth, then no danger may be

apprehended in allowing it to mature, but if the primary purpose is not to secure the full benefit of the clover crop, but rather to ensure the growth of the succeeding crop, whether it be corn or peaches, pears, plums, etc., then the use of the crop, its time of plowing down, should be made when it will not interfere with the primary purpose in its growth.

Fall Green Manure Crops.

In the case of crops that are grown during the summer the considerations in reference to soil still hold true, and even in a greater degree, since crops plowed down during the summer are more liable to rapid fermentation than those plowed down in the spring. Trouble from soil acidity may result from plowing down in the late summer or fall crops grown in the summer, still, the results of such practice will depend considerably upon the time that they are turned down and the character of the weather which follows. Cow peas, for example, that have been seeded in July and have grown through August and September may be plowed down in October without any danger to the succeeding crop or soil, unless the weather conditions are very unfavorable, as, for example, dry and hot, in which case the dangers pointed out in the turning down of the rye in the spring in its mature state would be likely to follow. Otherwise, if the weather should continue moist and hot, the rapid decay of the vegetable matter would be likely to result in a too rapid fermentation, probably inducing acidity of soil; this would not be likely to be a real danger except upon very light, open soils. On heavy clay soils, where the texture is more dense the tendency would be to prevent the too rapid entrance of air, and thus cause a more uniform decay.

When to Lime.

Where the crop is very large and where the conditions pointed out here are anticipated, the better practice will be to remove in part at least the burden of crop. It is desirable, also whether in the spring or fall use of the manure crops, to see to it that there is sufficient lime in the soil to assist in the fermentation, as well as to neutralize acids that may be developed. Hence, where green manuring is practiced, there is greater need of the occasional application of lime. It is not necessary that it shall be applied in all cases, since the application of, say 25 bushels of stone-lime per acre, in a rotation once in four years, would be likely to meet all the needed requirements for lime. If these suggestions are observed in reference both to soil inoculation and the plowing in of the green crops, there is no question as to the advantages that may

be derived from the practice. It will result, not only in building up soils poor in that important element, nitrogen, but will contribute materially to the improvement of their physical character, the water-holding capacity, and their consequent crop-producing power. On soils rich in potential fertility, the continued and judicious use of green manures will materially improve the mechanical character of the soil, not only, but will be very influential in the maintenance of fertility, without large additions of the minerals, phosphoric acid and potash.

The Amount of Nitrogen Contained in Average Crops.

While it has already been pointed out that it is very difficult to estimate the amount of nitrogen that the leguminous crops will draw from the air, the following tabulation shows the nitrogen and organic matter that are contained in an ordinary crop of the various plants:

	Ton Per Acre. Green.	Nitrogen. Lbs.	Organic Matter. Lbs.
Cow peas, ...	6	48	1,920
Soy beans, ...	6	60	2,640
Crimson clover, ...	6	60	2,160
Alsike clover, ...	6	60	2,640
Red, clover, ...	6	60	2,400
Canada field peas, ...	5	50	2,200

If the amounts of nitrogen indicated in the table as contained in a crop that can be harvested were all gathered from the air, there would be an undoubted increase in the fertility of the soil, as the amount of nitrogen gathered is equivalent to that contained in from 320 to 400 pounds of nitrate of soda, which amount would be regarded as a heavy dressing for even vegetable crops. Interpreted in terms of yard manure, the nitrogen and vegetable matter would be equivalent to from six to eight tons of average yard manure. It must be remembered too, that the yields given are not large, and that they do not include the amount of nitrogen and organic matter that may be contained in the roots and stubble, which in the case of the clovers is very considerable.

Furthermore, experiments have shown that the rapidity with which the organic matter will decay and give up its nitrogen to the cereal group of plants, is such as to make this source of nitrogen compare favorably with that contained in the average commercial fertilizer. The fact that so large an amount of nitrogen is introduced by means of green manures, whether entirely drawn from the

air or not, makes it important to use care, in order to prevent too large accumulations of this element. The danger, particularly in the case of certain cereal crops and fruits, is that the excess of nitrogen would be likely to cause an abnormal growth, that is, an undue leaf and wood growth. As in all other lines of farm practice, it is the judicious use of nitrogen that results in maximum returns.

Practical Application of Principles.

In order to give the most practical information to the farmer, the discussion of the use of the various plants described will be considered, first, in reference to those grown for the primary object of preventing losses in soils, and their consequent indirect improvement, due both to the saving of valuable soil constituents, and to the addition of vegetable matter; and second, in which the object of use is primarily to build up wornout or run-down soils, both in their physical character and their nitrogen content. In order that the matter presented may be directly applicable in present practice, it is necessary to select a method of practice now largely followed and which if continued will result in loss, and point out how the plants may be used and losses may be prevented, and what the gains are likely to be other than the saving of the food in the soil.

The Losses that May Occur in Rotation.

The common rotation of corn, oats, wheat or rye, and clover, may be taken as an example, because as usually conducted it is wasteful of fertility, due to the fact that no improving crops are introduced between the cereals, and only one in the rotation, and if the clover fails there is no renovating crop grown. By this practice it is impossible to prevent losses due to leaching, since the land is left bare for a part of two years. The sod land is used for corn, if it happens to be clover, the striking benefit of the clover in furnishing an abundance of nitrogen is apparent. The corn crop is usually harvested in early September, at a time in the season when, because of favorable conditions of weather preceding, namely, warm and moist, there has been an accumulation in the soil of nitrates due to the breaking down of the vegetable matter contained in the clover crop. After the removal of the corn, the land is left bare, except possibly a few annual weeds, the nitrates that have been formed and are ready to immediately feed another crop, and which are freely movable are carried away into the drains by the heavy rains liable to come in the fall. If heavy rains do not come in the fall, then the spring rains, which come before another crop is planted, carry at least a part of the nitrates so essential for the

nourishment of the early seeded crop away from the soil. The further disadvantage is that with the soil bare during this period of five or six months, the mechanical losses due to the high winds of winter and spring and to the washing of the surface are very considerable, especially on light land.

The losses that have resulted because of these conditions leave the soil depleted of a part of its active constituents, hence when the oats are seeded in the spring the crop may start promptly, due to the nourishment contained in the seed, but this consumed, the young plants soon become hungry for food, the available nitrogen which is necessary for a rapid growth is lacking and it does not make proper development until the conditions of warmth and moisture are again favorable for causing changes to take place in the soil, unless directly fertilized or manured. After the oat crop is removed, usually about the middle of July, the land lies bare again until the seeding of wheat or rye in September. During the summer season, the losses from leaching are not likely to be so serious, except in seasons of unusual rainfall, but if not wet, the weather is usually very hot; the rays of the sun strike direct into the soil and the temperature, particularly if it is sandy, rises very high—the soil becomes dry and hot, in which case the organic life present in the soil is likely to be destroyed. That is, because of the high temperature at this season the soils are not improved by lying bare, but rather injured, and when the fall crop is sown, instead of an accumulation of available food in the soil, for the wheat or rye, there is a deficiency, because the agencies active in promoting changes of dormant into active foods have been in part destroyed. The succeeding year crops must, therefore, be fertilized to ensure a good start, and a sufficient root-hold upon the soil to carry them through the winter. These, in brief, are the unfavorable conditions in a rotation of this sort, a rotation in many ways a desirable one, but which as ordinarily conducted results in a rapid exhaustion of soil, though one which permits of great improvement if properly modified by the use of catch crops.

The Use of Catch Crops Improves the Rotation.

In order to prevent losses, as well as to provide for an accumulation of food in the soil, the following suggestions are made: In the first place, crimson clover may be seeded in the corn, just before the last shallow cultivation, at the rate of 12 pounds per acre. If the seed is well covered it will germinate very quickly, though the plants may not make much growth until after the corn is removed, owing to the rapid absorption of food and moisture by the corn in the last stages of maturity. The plants will, however, then start

up and grow rapidly and if the weather is favorable often cover the ground with a mat six or eight inches thick, filling the entire surface soil with fine rootlets, which absorb and hold fast to the available nitrogen already there, and which would otherwise be lost, besides, they would acquire from the air a part at least of the nitrogen which is so valuable an element. This crop would, too, hold fast to the soil and prevent mechanical losses due to washing, so liable to occur in winter.

In many cases it is desirable to pasture because the large fall growth of the clover, if not removed, will increase the danger of smothering in winter. Should, however, the conditions not be favorable and the plants die before spring, the nitrogen in the fall crop, either absorbed from the soil or accumulated from the air, will amount to an equivalent of five to six tons of yard manure per acre, in addition to the improvement of soil due to the considerable organic matter in the crop. The crop may be turned under at any time when it is convenient for the oats which follow the corn, thus not interfering in any way with the rotation, though naturally the amount of food gathered for the oat crop will be small, owing to its early seeding. The gain here is chiefly due to the prevention of losses. When there is injury to the clover crop, due to very dry weather following seeding, or because of unfavorable conditions which make careful seeding impossible, the advantages gained by the use of this crop may be in part attained if with the clover is mixed seed of the turnip, or Dwarf Essex rape, a half pint of seed per acre of each of these plants, used with the clover seed, using the same amount of clover, will be sufficient to give a considerable number of plants per acre, and will not interfere with the growth of the clover, should the conditions be favorable for its development, and if not, then the covering of the soil by the plants of the turnip and rape will be sufficient to absorb and retain food that is liable to be wasted, besides there will be an accumulation of vegetable matter useful in the improvement of the soil and in the feeding of other crops. The soil will be covered, even though the plants die, with a mulch of vegetable matter that will prevent the washing and mechanical losses due to heavy storms. Where neither crimson clover, turnips or rape are regarded as available plants for the purpose, then rye or wheat may be seeded at the last cultivation of the corn, at the rate of one and one-half bushels per acre.

By this method of practice a growing plant of the "nitrogen consuming" class is used, which will in its growth hold fast to the available food liable to be lost, besides filling the ground with roots and preventing mechanical losses. This crop may be turned under

early in the spring without interfering with the rotation, though naturally the only gain will be the saving in the soil of food that would be liable to be lost. The chief advantage of the nitrogen consuming crops when used for this purpose, has been, as will be observed from the previous discussion, is to hold fast to food that may be lost, as the growth of the crops will not in any large degree increase the constituents in or improve the properties of the soil, as the oats seeded early in the spring will prevent the crops from making any considerable accumulation of food from soil and air.

The next point to be considered is the protection of the soil, as well as its possible improvement after the oats are harvested, and before the succeeding crop is planted. It is preferable in this case, of course, to use a plant which will accumulate nitrogen from the air, renovating rather than exhaustive in its character, as the crop which follows, namely, wheat or rye, is a nitrogen consumer, whose entire and only source of nitrogenous food is the soil. A nitrogen consuming crop, as millet, for example, or even buckwheat, would use too completely the available food in the surface soil, converting it into organic forms and hence make the conditions of soil less favorable for the wheat in respect to available plant food, than if the crop had not been grown. Furthermore, a crop must be grown which develops rapidly, in order that a large accumulation of nitrogen and organic matter may be made in a short time, say six weeks or two months. For this purpose, therefore, no better plants can be suggested than the cow pea or soy bean.

It is not necessary in the seeding of these plants that the land should be plowed after the oats are removed, if the surface two or three inches of soil can be made fine with a Cutaway harrow, in fact, this is a better practice than to plow, as the losses of moisture due to the preparation will be much less and the possible effect of dry weather in part avoided. Hence, immediately after the oats are removed prepare the land and seed cow peas or soy beans at the rate of one and one-half bushels per acre; they may be broadcasted, harrowed in, or put in with the grain drill, and preferably dressed with 250 pounds per acre of a mixture of four parts of acid phosphate and one part of muriate of potash. This added fertility is to ensure an abundance of available mineral food, so necessary in order that the plant may be induced to appropriate nitrogen from the air. This, of course, will remain in the soil for the use of the wheat or rye, which follows. At this season, if there is sufficient moisture, the plants germinate quickly and grow rapidly and will in six weeks make a considerable crop.

The advantages of growing a crop of this character are, first, that the soil is very soon covered with a plant of a large leafy growth,

thus protecting the soil from the direct rays of the sun, and preventing the destruction of organic life, due to hot and dry conditions, and in the second place, there is an accumulation of nitrogenous vegetable matter, which when plowed into the soil is useful for the succeeding "nitrogen consuming" crop; and third, there is no interference with the growth of the regular crops of the rotation. That is, even though the period of growth is not long enough to cause the complete development or full maturity of the plant, it can be turned under when convenient, with the satisfaction of knowing that even though a small crop has been secured the soil is better, both physically and chemically, for the growth of the following wheat crop than it would have been if the land had been left bare.

Failures Should not Discourage.

As in the case with a number of other crops, failures sometimes occur, particularly in the catch of crimson clover. This is not always due to the season, though frequently such is the case. It is my judgment that the failures are more frequently due to the lack of proper preparation of the soil and seeding. In many cases the plants are starved in the beginning because the rapid growing of the corn absorbs the food and moisture, hence, if the seeds are placed deeply the danger from this source is not so great. It often happens too, that the preparation of the land for corn and its cultivation have not been of the best; the land is hard and cloddy and thus too little food is available for the clover. Sometimes, too, the soil may be slightly acid, which would make it an unfavorable medium for the growth of the soil organisms, whose presence have so important a bearing upon the growth of the crop; strict attention to those points which are important in the growing of any money crop is quite necessary in the successful growing of catch crops. It is recommended that where failures have occurred that the seed be covered more deeply and that in the preparation for corn the land be well tilled and preferably limed, say at the rate of 25 bushels per acre, either the year before planting on the sod, or early in the spring after plowing, and well harrowed in, and on land not in a good state of cultivation, this practice should be followed by a broadcast dressing of acid phosphate at the rate of 250 pounds per acre. The lime will neutralize the acidity of the soil, the acid phosphate will ensure an abundance of available phosphoric acid for the plant, which requires considerable in its early growth and a deeper seeding will cause a better hold of root and enable the plant to withstand a lack of moisture, which is one chief difficulty encountered in the seeding with corn. In the growing of the cow pea, after oats, it is very desirable if the best results are to be obtained,

that the plant have at its disposal a sufficient amount of available phosphoric acid; the addition of this for the benefit of the catch crop will not be lost, but be recovered again by the crop of wheat, and by making conditions favorable for the growth of the cow pea the plant is in a position to fully exert its function in the way of appropriating nitrogen.

Danger of Injury to Soil by Green Manuring.

A word of caution should be given concerning the turning under of green crops as manure. If the conditions of season are not favorable, i. e., too warm and moist, the land may be injured rather than benefited by the turning under of so large a mass of material. It may ferment or change too rapidly, the rapid decay developing an acid, which may be so great as to cause injury to the soil. If, on the other hand, it is too dry, the crop does not decay for some time; a mass of vegetable matter lies between the surface and subsoil, which prevents capillary attraction, and results in a greater drying of the surface soil than would be the case if no crop had been grown. In either of these cases the possible disadvantages should be recognized. Hence, where a crop of some size is turned under in hot weather it is desirable to add lime, which will neutralize the acid and assist in the decomposition of the vegetable matter. If the crop is too heavy, a part at least should be removed and great care taken to thoroughly "firm" the soil after it has been turned down. It is also well to remember that a too frequent turning under of heavy green manure crops will rapidly increase the soil's content of nitrogen, and unless large applications of minerals are made, the soil may become so rich in this element as to cause too great a leaf growth of the cereal plants. When this stage is reached the practice should be changed, the crop of cow peas should be used as before, but preferably used as forage or made into hay, and only the roots and stubble turned under for the wheat. The chances are that in most cases this would be the better practice from the standpoint of soil improvement—it certainly would be a more economical method of practice where the forage can be used to advantage.

The Application of the Principles in Other Rotations.

The principles that have been pointed out in this discussion relative to the addition of crops that may be used in this rotation, in order to improve the soil, hold true for other crop rotations, when the land is left bare for any considerable period, and also in reference to the improvement that may come from the introduction into the soil of considerable vegetable matter containing nitrogen, which

has not been drawn from soil sources. Still, suggestions as to changes in practice which may result in increasing the area and yield of more useful crops may be of service. For example, in growing corn, it has been demonstrated beyond a doubt that this crop may be grown on good land many years in succession on the same land, while at the same time maintaining, if not increasing, the yield of crop, provided a crop of crimson clover is grown and plowed down. That is, because of the holding fast of the soluble constituents liable to be lost in fall and spring, and because of the accumulation of vegetable matter and of nitrogen, by virtue of the clover crop, the corn is supplied with a greater abundance of mineral elements and of nitrogen each year, and the soil is not exhausted of its vegetable matter.

Soils naturally rich in minerals, with the improved physical character, due to the introduction of the catch crops, will provide the corn plant with a full supply from year to year without direct or heavy applications of fertilizer supplies. This practice would be very desirable on dairy farms, where a large yield of corn for the silo is an important factor. It may be modified still further and made more profitable by using a part of the clover instead of turning it under, as in the middle States the clover will be ready to harvest from the middle of May until the first of June, depending upon the season, or in time to permit the proper maturity of corn planted after that date. Hence, when the clover is seeded for the purpose of using in part on pasture, forage or hay, the land should be cultivated as nearly level as possible, and the corn stubble broken down or rolled off in winter. The crop may be pastured earlier than any other clover, and it may be cut for green forage or hay by the 20th of May, or in time for the planting of another crop. The removal of the clover, of course, results in reducing the amount of vegetable nitrogenous matter introduced into the soil, and for best results the soils should be matured in addition to the application of the mineral constituents, though in many cases the harvesting will be imperfect and a very sufficient amount left to considerably increase the supplies for the corn crop.

Where the rotation consists of corn, late potatoes, wheat and clover, the crimson clover seeded in the corn may be allowed to partially mature, thus making a very considerable addition of food to the soil for the potato plant. This is a very excellent rotation, resulting in very materially improving the soil, particularly when the potato crop is a profitable one, as it enables the use of two clover crops, both contributing to soil improvement, besides, the potato is not an exhaustive crop. In this rotation the cow pea could not be readily introduced, as the wheat should be sown almost immediately after the potatoes are removed.

Modifications of various rotations may be adopted and the usefulness of the proper catch crop very easily demonstrated. The main points to be observed is to keep the soil covered between crops with a leguminous crop, if possible, but with some crop, in order to be sure of this; in the case of the corn a mixture of the crimson clover and other seeds, as turnips or rape, may be made, so that the catch is there in any case, though if only the fall growth is obtained, the advantages of a fall covering are many, namely, a very handsome return is obtained on the investment for seed and the labor involved.

Improvement of Poor or Rundown Soils.

Where soils are poor, and the primary object is to build up or make "condition" rapidly, rather than to secure money crops, the leguminous crops should be more generally and continuously used. The land, for example, which has been run down, lacks both chemical and physical character. The crops grown have been exhaustive, the land badly cultivated and condition such as to make it unprofitable to use direct fertilization for the purpose. The questions are what crops shall I use and how shall I use them to the best advantage in order that money crops may be grown the second year?

If it is necessary to begin in the spring, the first crop used may be the Canada field pea. This should be seeded deeply, as early as it is possible to prepare the land, at the rate of about two bushels per acre, and the land should preferably receive a dressing of say 500 pounds of a mixture of 400 pounds of acid phosphate and 100 pounds of muriate of potash per acre. This crop may be plowed down, in our middle States by the first of July, and may be followed immediately by a crop of cow peas, seeded as already recommended and without further fertilization, and this crop plowed down by the middle of September, the land preferably limed at the rate of 25 bushels per acre, obeying in both cases the precaution to thoroughly "firm" the soil by rolling. This may be followed by a seeding of rye and sand vetch, one bushel of rye and one bushel of vetch, preferably fertilized with a dressing of 200 pounds of acid phosphate and 200 pounds of ground tankage per acre, preferably to secure a good catch and growth of rye. This combined crop may be turned under in spring for corn, without the further addition of fertility elements, and a rotation, the adoption of which is suitable to soil and conditions, provided it permits of the introduction of leguminous catch crops.

Here we have in one season, or previous to the planting of the corn, three crops of a leguminous character, which should very materially change and improve the character of the soil, making a

heavy soil more open and porous and absorptive, and a light soil more compact and retentive, besides furnishing a very considerable percentage of nitrogen available for the succeeding crops. Naturally, if the soil is poor it will be necessary to continue with as many leguminous crops in the rotation as it is possible to introduce. For a year or two at least, keeping the number of money crops in the rotation as low as possible.

The object of this work is to point out, so far as it is known to the writer, the principles involved in the natural improvement of soils; with these understood the individual farmer will be better capable of selecting his crops useful for the purpose than any one else, as he is familiar with his climatic and seasonal conditions, his own soil and its adaptation for the various crops, both "catch" and "money." He should remember, too, that the knowledge of these things is yet very incomplete and that he must not rest satisfied with the improvement that may be obtained by its use, but to take advantage of such further additions as may be made from time to time, as the resut of scientific investigations.

THE FUNDAMENTALS OF SPRAYING.

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INTRODUCTORY.

Although the literature on spraying has become extensive since the introduction of the practice of treating trees and plants with insecticides and fungicides, there still remains much to be told to the ordinary grower of crops. In general, it may be said that the matter put forth has not been detailed enough. While the subject has been fully exploited so far as the desirability of spraying and the kinds of substances and compounds to be used are concerned, the many little points and details which go so far to make successful results possible have for the most part been overlooked in the effort to accomplish greater things. It will be the purpose of this bulletin to take up and consider the fundamentally important details of spraying, and attempt to explain the principles involved, so as to render it possible for the growers to think and act for themselves; thus enabling them to proceed intelligently and effectively in this important line of horticultural work.

Spraying is perhaps the most expensive of our orchard practices. For that reason it is very likely the most generally slighted of all horticultural operations. It is, on the other hand, the most exacting in its requirements. For without the most intelligent and painstaking care in every detail of the work, the efforts may lead not only to ineffective but even to negative results.

Importance of Timely Work.

In the first place the application must be timely. It will not do to put off spraying work until some other farm duties have been done, and then go out and squirt around in a hit and miss sort of fashion. The time when an insect or fungus can be successfully combated is, in most cases, exceedingly short. Often a difference of a day or two is sufficient to change success into failure. Thus in the case of codling moth, for example, it is impossible to reach the worm after it has gotten well into the fruit. As its first efforts are directed towards burrowing into the fruit, it is essential to have a poisonous dose on hand as soon as the worm is hatched. Moreover, *Slinger-

*Cornell University Experiment Station Bulletin 142, p. 21.

land has shown that most of the insect's feeding before it enters the apple is done in the calyx cavity between the calyx lobes, where from 75 to 90 per cent. of the worms go in. It is important, therefore, to have the calyx cavity well charged with poison. Formerly it was supposed that this could be accomplished at any time before the young fruits turned down. Slingerland* has pointed out the fact that the calyx lobes of the young apples close over the cavity in from seven to ten days after the blossoms fall. (See Plate I.) After such closing, it is practically impossible to get the poison into the cavity. The importance, then, of completing the application before the closing takes place is emphasized. To the owners of large orchards this is especially important, for it means that sufficient apparatus must be provided to enable the spraying of the entire place before the expiration of the period mentioned. So it is also with the great majority of fungous diseases: It is impossible to reach them when once they have penetrated the skin, as will be explained later.

General Classes of Mixtures.

There are two general classes of spray mixtures, viz:

1 Insecticides.
2. Fungicides.

The first class includes all mixtures used for the destruction of insect pests; the second includes all applied against fungous diseases.

Classes of Insects.

Every fruit-grower or farmer knows what an insect is. But not every fruit-grower or farmer knows that the insects attacking fruits and plants are of two general kinds They are; and the two classes are as follows:

1. *Chewing insects*, or those which have biting and chewing mouth-parts. These take in and digest solid food, usually the leaves or fruit of plants. Such are, for example, the codling moth, canker worm, web worm, tent caterpillar, leaf skeletonizer and the like.

2. *Sucking insects*, or those which have sucking mouth-parts. These suck the juices of the plant and therefore live entirely upon liquid food. These are the plant lice, scale insects and the like.

Naturally, then, the life habits of these classes of insects demand very different methods of spraying in order to destroy them. The first class can be reached through their food supply, and are, therefore, easily destroyed by poison eaten along with the parts of the plant attacked. The second class cannot be reached through their food supply, as they derive their sustenance by sucking the juices from within the plant tissues. They can, therefore, be destroyed only by contact with some caustic or suffocating compound. There are, therefore, two classes of insecticidal sprays:

*Cornell University Experiment Station Bulletin 142, pp. 54 and 55.

Poison sprays, such as Paris green, arsenite of copper, arsenite of lime, arsenate and arsenite of lead, and arsenical poisons generally. These are effective against the first class of insects only.

Contact sprays, such as kerosene, crude petroleum, the lime, salt and sulphur wash, whale oil soap, rosin wash, pyrethrum, and tobacco. These kill the insects by their caustic action or by closing up his breathing pores and thus suffocating him. The second class of insects can be destroyed only by these. Insects of the first class may also be destroyed by contact sprays, but only in rare cases is this class of mixtures so employed.

Fungi.

In order to understand fully the action of remedies against the other class of enemies which the fruit-grower has to combat, the fungi, it will be well to consider somewhat in detail the definition of a fungus—just what it is, how it lives and grows.

What is a Fungus?—A fungus is first of all a plant. It belongs to a lower order of plants, differing essentially from the more familiar "higher" plants in possessing no chlorophyl, or green coloring matter. It is incapable of assimilating inorganic (mineral) substances, and is therefore dependent upon organic matter either living or dead, upon which it grows and derives its sustenance just as the higher plants derive theirs from the soil. It has no leaves, but it has something akin to roots and stems, the mycelium, and its means of reproduction and spread, the spores, analogous to the seeds of higher plants. The spores are perhaps the most important part of the fungus from the point of view of the fruit-grower, for it is by the means of these that the disease or destruction by the fungus is spread from leaf to leaf, from fruit to fruit, or from tree to tree. Any agency, then, which may disseminate the spores may be the means of spreading the disease caused by the fungus. Wind, rain, insects, birds, animals and even man himself are known to act in this capacity.

How a Fungus Grows.—Now, what takes the place when one of the spores falls or is placed upon a leaf or a fruit? If the conditions of temperature and moisture are favorable it will germinate—just as a seed does when planted in moist, warm earth—and send out a small tube, known as the "germinating tube" of the fungus. These spores with their germinating tubes are exceedingly small and can be seen only with a compound microscope. Plates II (*a*) and II (*b*) are reproduced photo-micrographs of bitter rot spores before and during germination, all greatly enlarged. From this point fungi differ in their development, in the manner in which they grow and extract their nourishment from the parts of the host plant attacked. In one class the germinating tube

(a) A pear and two apples just right for spraying, the calyx lobes spreading and open, just after the petals have fallen.

(b) One week after the petals have fallen. Almost too late to spray the apples, the calyx lobes having almost completely closed over the cavity. The middle fruit is that of a pear, which closes little, if any at all.

PLATE I.

Apples just after the petals have fallen and one week later.

(From photographs by Slingerland, Cornell Experiment Station, Bull. 142, pp. 54 and 55.)

(a) Before germination.

(b) During germination.

PLATE II.

Bitter Rot Spores, as seen under the Microscope.

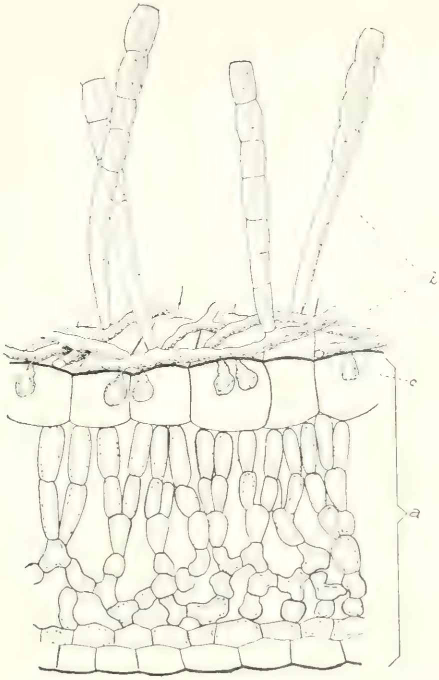


Fig. 1. Greatly enlarged cross section of rose leaf (a) affected with an external fungus, the powderly mildew. Both the mycelium and spores (b) are entirely external. The fungus sends suckers (c) into the epidermal cells to get nourishment.

(Drawing by H. Hasselbring of the Illinois Experiment Station.)

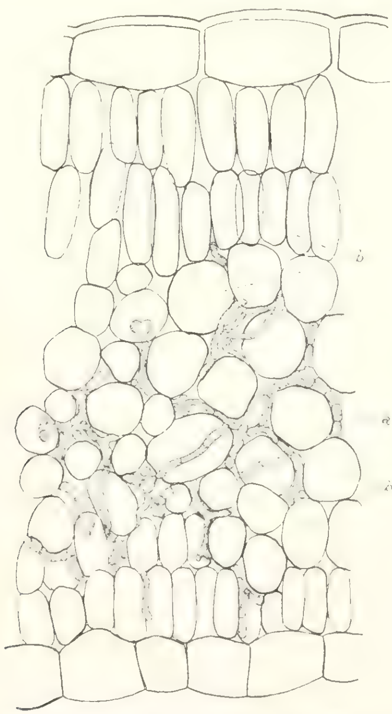
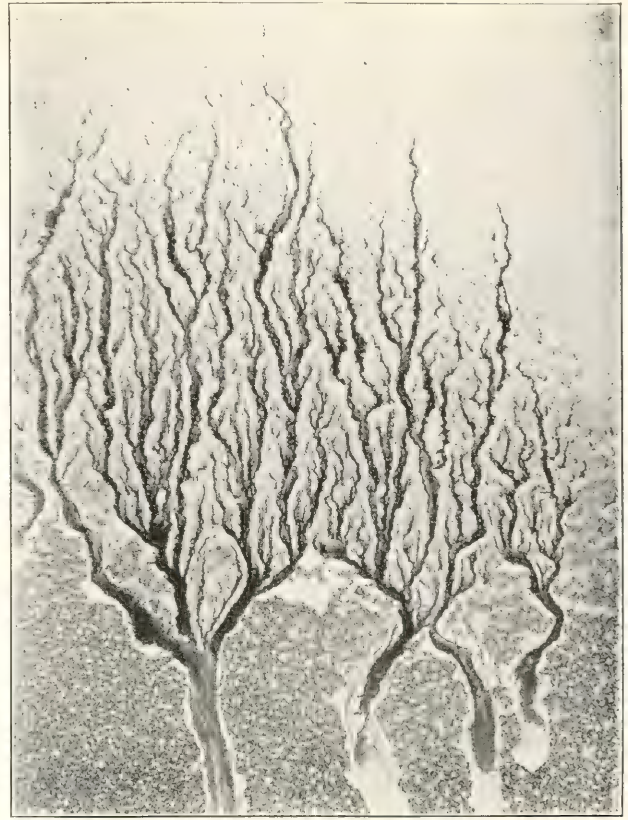


Fig. 2. Greatly enlarged cross section of carnation leaf affected with an internal fungus, the carnation rust. The mycelium (a) grows wholly within the leaf between the cells (b). Only the spores appear at the surface.

(Drawing by H. Hasselbring of the Illinois Experiment Station.)

(a) Sprayed to the proper point.



(b) Sprayed too long or drenched.

PLATE III.

Glass Plates showing the effect of proper and improper spraying.

(From Bulletin 68 of the Ill. Exp't Station.)

(a) Sprayed to the proper point.

(b) Sprayed too long, or drenched.

PLATE IV.

Apples properly and improperly sprayed.

(From Bulletin 68 of the Ill. Exp't. Station.)

PLATE V.

Apple leaves showing the results of the accumulation of the spraying material at the edges by running down and evaporating. The dark edges and spots represent dead patches on the leaves.

(From Bulletin 68 of the Illinois Exp. Station.)

begins to branch out and continues growing upon the *surface* of the leaf or fruit, leaving its mycelium exposed. These are known as external fungi, and are by far the easiest class of fungous diseases to combat. (See Fig. 1.) For it is obvious that the fungicide can be applied directly to the mycelium. In this way the fungus can be destroyed and its further development prevented. To this class of fungi belong the powdery mildews of the grape, the gooseberry and the rose.

In the other class of fungi, the internal fungi, the germinating tube penetrates the skin and there branches. Thus the mycelium is developed within the tissues of the parts of the plant attacked. (See Fig. 2.) It is obvious, then, that the mycelium is wholly out of reach of any spraying compound, and, therefore, once the fungus has gained entrance it is practically impossible to arrest its development. The remedy can be only preventive in its action. The fungus must be killed before the germinating tube enters, otherwise all effort is lost. This is so fundamentally important that it will bear the strongest emphasis. In addition to this it must be pointed out that the most commonly used fungicide, Bordeaux mixture, does not destroy the spores themselves. It is the little germinating tube only which is destroyed by the fungicide, and, therefore, before the remedy can be effective, the spore must germinate. Hence, the necessity of having the remedy applied in time becomes doubly important, for the germinating tube must be destroyed before it penetrates. The dedevelopment of the disease will continue, despite the presence of the remedy applied too late, and complete its life history by producing new crops of spores ready to spread the disease anew. The downy mildew of the grape, the scab, the fruit rots, the cankers—in fact, most of the fungous diseases which afflict trees and plants in this region of the United States come under the head of internal fungi, and must be dealt with accordingly. Remedies should be applied before the fungi of this class have gained a firm foothold. Spraying should be begun upon the first appearance. It is not necessary to wait for it to make a "showing." Otherwise, the spores may become so extremely abundant that, relatively, a large proportion of them may escape the fungicide and thus complete their mission of destruction.

Classes of Fungi Summarized.

To summarize briefly, therefore, regarding fungi, it is seen that there are:

External fungi.—powdery mildews of grape, rose and gooseberry—which develop on the surface or outside and which are thus comparatively easily killed at almost any stage of their growth by fungicidal mixtures coming in contact with their exposed mycelium. (Fig. 1.)

2. *Internal fungi*—downy mildew of grape, scab, fruit rots, canker, etc.—which continue their development wholly within the tissues of the parts attacked and which are thus prevented from developing only by destroying the germinating tube of the fungus before it penetrates the skin. (Fig. 2.)

Physical Properties of Mixtures.

In order to know just how to use and apply the different spraying liquids now in common use, it is necessary to understand and appreciate their physical properties, their behavior in the tanks, in the pump, at the nozzles and on the plants. To do this most conveniently, spray mixtures may be divided, irrespective of their insecticidal or fungicidal properties, into three general classes:

1. Mixtures involving the suspension of insoluble substances in water; for example, Paris green and other arsenites, Bordeaux mixture.
2. Mixtures consisting of simple solutions; for example, copper sulphate solution, ammoniacal copper carbonate, sulphide of potash, different soap solutions, solutions of lye or caustic soda.
3. Emulsions or mechanical mixtures of oily or waxy substances with water; for example, kerosene and crude oil emulsions, or the kerosene and crude oil mixtures with water through the medium of the pump and nozzle, without the aid of emulsifying agents.

Mixtures Consisting of Insoluble Materials in Suspension.

In the mixtures of this first class, insoluble substances are to be suspended in water and applied while in suspension. It is important to bear this in mind, as upon this fact depends not only the method of application but also the method of maintaining the compound on the fruit or leaves, as the case may be. It is necessary that the mixing be thorough in order that the material may be equally disseminated throughout the liquid. For unless it is, the distribution of the poison or fungicide will not be uniform, and hence effective results cannot be obtained. The insoluble material is kept in suspension by means of agitating the liquid either by a separate agitator or by a devise attached to the pump handle.

Agitators Considered.

The proper and thorough agitation of sprays of this class is one of the most important points in the successful use of the materials

so used. The agitators now in common use are far from perfect and unless carefully watched are often the cause of failures. It has now come to be almost the universal custom to attach the agitating device to the pump handle, so that the liquid is stirred with every stroke of the operator. This at first sight seems a good plan. In some respects it is, for it at least secures some sort of agitation which is better than none at all. But the labor of pumping, so as to keep the pressure up to the required mark, is really heavy enough without adding to it the extra work of keeping a properly constructed agitator at work. Then, too, the two motions can hardly be coupled to advantage. For the pumping, a long, steady stroke is best, while for thorough agitation a quick, abrupt stroke is preferable. It is very much better, therefore, to have the agitating device separate from the pump. In this way a few vigorous strokes or turns of the handle accomplish a great deal better work than the slow dipping of a paddle. Agitators having a whirling paddle with tilting blades arranged somewhat like a screw propeller are, on the whole, the most satisfactory. (Fig. 3.) With this instrument the liquid is given a whirling upward motion, which very effectively dislodges the material from the bottom and sides of the tank. On the long, flat tanks now in general use it is practically impossible to secure thorough agitation throughout the liquid by any device which may be attached to the pump handle. For these tanks the agitator should consist of a set of two or three paddles so arranged that they will keep the whole body of liquid in violent motion. These paddles should be attached to a lever or handle on top of the tank. Where Paris green is used alone, the agitation must be continuous while the pumping is going on, and in order to insure its thoroughness it would pay to put on an extra man or boy to run the agitator. With properly prepared Bordeaux mixture (as will be explained later) continuous agitation is unnecessary. Merely stirring the liquid from time to

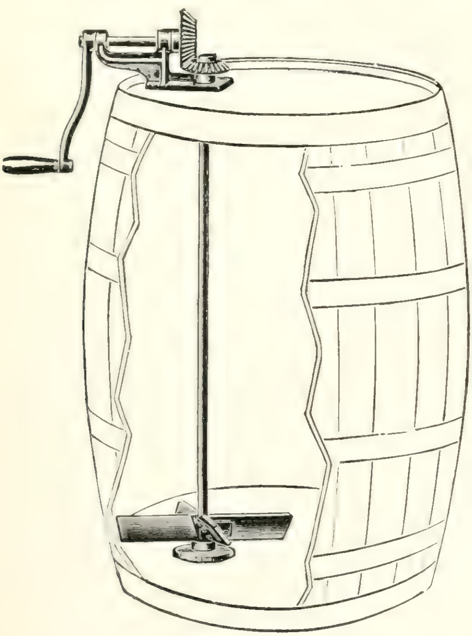


FIG. 3.

time is amply sufficient to keep the precipitate in suspension. This can best be accomplished while the rig is moving from tree to tree, thus allowing one man to do the whole work. Some growers in New York have rigged up attachments on the wheels of their spray wagons which turn the agitating device and thus do away with this extra hand labor. Where Paris green is used combined with Bordeaux mixture, the latter helps to keep it in suspension and no further agitation is needed than for the Bordeaux alone.

Proper Placing of Pumps on Barrels.

Most of the pumps are now placed on the end or head of the barrel. For use in applying mixtures consisting of suspended materials—especially Paris green—it is very much better to place the pump on the side of the barrel. When the barrel is laid down on its side, as it must be in that case, a bottom with a depression at the center is formed by the sloping sides. Most of the settling will go towards this depression and thus there will be really a smaller settling area than that afforded by the flat bottom. Moreover, the flat bottom and straight sides, when the barrel is used upright, offer some resistance to the movement of the liquid, while the sloping bottom, in the case of the barrel on its side, offers little resistance and thus aids rather than retards in the movement of the liquid. In order to see how difficult it is to dislodge a comparatively heavy substance, such as Paris green is, from around the sides of a barrel bottom, place a small quantity of the poison in a flat-bottomed tumbler and attempt to keep the material in suspension by stirring. It will be found that it requires rather vigorous stirring in order to dislodge the green from the bottom and keep it from settling around the sides. If this little experiment is performed, it will be well to note how very much more effective is a whirling motion over a simple dipping, illustrating the advantages of the whirling-paddle agitating device.

How to Spray Properly.

To spray properly is an art requiring both skill and intelligent care to accomplish it successfully. Moreover, it is of the greatest importance; for no matter how carefully the mixtures may be compounded or how nearly up to purity standards are the ingredients used, full success is practically impossible unless the mixtures are properly applied. It is not enough to go out with a vim and determination "to do an everlasting good job" and give everything a drenching. This is not only wasteful but positively less effective than when a smaller quantity is properly applied; for when drenching is practiced there will finally be less material on the trees, leaves

and fruit than when a smaller quantity is properly put on. To many this may seem strange. But nevertheless it is a fact, and an attempt will be made to show just how it comes about.

In order to do this it will be necessary to study in detail what takes place in the drops of water after they leave the nozzle and become attached to the fruit or leaves. It will be remembered that the material is to be kept in suspension and equally disseminated throughout the whole mass of liquid in the tank. Consequently, each minute globule of water as it leaves the nozzle will carry with it a certain amount of suspended Paris green, Bordeaux mixture, or both, as the case may be. Now, the settling which goes on in the spray tank takes place also in the globule of water after it becomes attached to the leaf or fruit. Therefore, it is desirable to have each globule of water deposit its suspended material at the place where it is attached to the fruit. But liquids have what is known as "surface tension;" that is a force exerted from within which tends to keep a small globule of water intact. Beyond a certain size this force is unable to keep the globule intact as such. Then it will not remain where it strikes the surface of the fruit or leaf, but will run down to the lowest point and there drip off. This happens when the globules are too large or if the smaller ones are brought so close together that they run together to form one or several large ones and the same running down and dripping-off results. This running-together may be easily seen by breathing against a cold window pane. First, it will be noticed that the globules of condensed moisture are exceedingly small, each one, however, remaining separate and distinct. Now continue breathing against the moist spot. The globules of moisture increase in size until a point is reached where they run together and form one large globule spread over the surface of the glass. But now, instead of remaining spread over the glass, when it is in a vertical position, the large globule runs to the lower edge of the pane, and if there is moisture enough, will drip off.

This is exactly what takes place on the surfaces of leaves and fruit when the spray liquid is applied. The globules are at first deposited as separate, fine "dew drops," covering the entire surface. This is the ideal point to be reached, and as soon as it has been accomplished no more liquid should be applied. If more is put on, the small drops run together and trickle down to the lowest point. It has been said that the settling of the material takes place in the globule of water after it becomes attached to the fruit. The larger the globule, then, the more settling will take place. It has also been seen that the settling goes to the lowest point. Consequently, if the globule is spread over a large portion or the entire surface, the settling will naturally go to the lowest place in this instance also, and as the low-

est point is where the water drips off, the sediments go to that point and drip along with the liquid, thus leaving actually less material on the fruit or leaf than when a smaller quantity is properly applied. Or, if it does not drop off it will accumulate at this lowest place, often in quantity sufficient to cause injury, while the upper portions are left bare and thus exposed to attack.

Plate III illustrates the running together and settling to the lowest point. This effect was produced by spraying two glass plates, (*a*) just to the proper point and (*b*) beyond that point until the globules ran together. In (*a*) it will be noticed that the surface of the glass is uniformly covered by the dried material. But note what took place when the spraying was carried beyond the proper point. The globules ran together and the liquid flowed down in little streams and carried with it the suspended material, leaving bare streaks, and either accumulating it at the lowest point or carrying it away where it dripped off the plate.

It must be emphasized that the material must be so applied that it forms an *unbroken* thin coating over the entire surface of the leaf or fruit. This is especially true of the Bordeaux mixture. That remedy, as has been shown, is wholly preventive in its action. Any breaks in the coating are exposed to attack, and if attacked, become centers of infection, the birthplace of new crops of spores, thus increasing the chances for new infection. The more numerous the spores, then, the more carefully must the application be made, for when the spores are very abundant the chances for some of them to settle on the exposed places are correspondingly greater. Plate IV (*a*) shows an apple properly sprayed. The photograph shows the distinct marks of the separate globules of mixture. In addition, there were many exceedingly fine globules too small to be seen in the picture. Plate IV (*b*) is an example of an apple which has been sprayed long enough to allow the globules to run together and drip off or accumulate in spots. Notice how unevenly coated is the surface. In an orchard where the fruit rot or the scab is very abundant an apple or a leaf sprayed as that one shown in the plate is little better off than if it had not been sprayed at all.

The injury due to the excessive accumulation from the material running down and evaporating at the lowest points has been mentioned. Plate V exhibits examples of leaves so injured. These leaves were taken from a tree sprayed with nearly ten times the usual strength of ammoniacal copper carbonate solution until the liquid began to drip. The leaves were badly burned around the edges and at the tips, while the leaves of another tree properly sprayed, or without dripping, were not injured at all by the same solution. Thus, it will be seen, that two evils may result from improper spraying:

Large spots may be left bare and exposed to attack, and injury may be caused by excessive accumulation in a few spots.

Only a pump capable of maintaining a high pressure should be used, and for this class of work the finer nozzles are called for. The liquid should be kept issuing as a fine mist—so fine that it floats in the air as steam or smoke. This is impossible under a low pressure, for the higher the pressure the finer will be the mist, other things being equal. The pressure should always, therefore, be kept at its maximum, if possible between fifty and sixty pounds, never below forty. With the liquid issuing as a fine mist, the nozzle should be held some little distance away from the tree and the mist allowed to float in and condense itself upon the fruit and leaves in fine globules, thus completely bedewing the surfaces.

Hence the importance of the injunctions: "*Use only a fine nozzle; use pressure enough to keep the liquid issuing as a fine mist, and spray only until the fruit and leaves are completely bedewed.*"

Mixtures Consisting of Simple Solutions.

Mixtures of the second class, or diluted solutions, are somewhat easier to handle, in that the problem of agitation is absent. But they have to be considered from two standpoints and must be handled differently, depending upon whether they are used as insecticides or as fungicides, or whether for internal or external fungi. If used as a preventive against one of the internal fungi, then all the precautions regarding the maintenance of a fine mist upon the fruit must be observed. Otherwise, the two evils mentioned above—the leaving of exposed spots and the injury from excessive accumulation in spots—will result. Plate V has already been cited as an example of damage from the latter cause. If, on the other hand, the solution is used against the sucking insects or external fungi, and therefore intended to destroy by contact, a different mode of application is called for. In these cases a coarser nozzle, throwing a more or less direct stream is desirable. The effectiveness of the spray is often increased by having it strike with some force. Here the rules mentioned above, regarding the maintenance of a fine mist, do not apply. Every part of the tree should be thoroughly wetted so as to have the spray come in contact with every insect and fungus spot. In this case the spray has usually done its work as soon as it strikes. It is not important, then, to have it remain on the trees; in fact, the reverse is often desirable. Of course, when strong solutions are used, there is danger of injury from the accumulation by evaporation at the lower edges of the leaves, or if the solution is allowed to run down the trunks and thus saturate the ground around the root

crowns. It is well, therefore to avoid waste when spraying in this way, and to carry the operation just far enough to wet every part of the trees or plants.

Emulsions.

The mixtures of this class are practically all used against sucking insects; scales, plant lice, and the like. A large proportion of these mixtures is also intended for winter use, when the trees are dormant, and are, therefore, not subject to the same rules as those used when the foliage is present. A more direct stream is desirable, for here, as with the simple solutions used for a similar purpose, the effectiveness of the spray is increased by having it strike with some force. A good many of the insects of the sucking class are protected by a woolly, hairy or waxy covering, which it is hardly possible to penetrate without projecting the spray against them. The writer has sprayed the plum aphis with kerosene and water through an ordinary fine Vermorel nozzle without effect; while the same mixture put on through a somewhat coarser nozzle as a direct stream proved wholly effective.

When kerosene and water or the crude oil and water are used the nozzle must not be too coarse. The mixing of the oil and water is accomplished at the nozzle. If the nozzle is too coarse, therefore, the mixing will not be thorough. The aim in the use of this class of mixtures is to secure a thin coating of oil over the tree—the thinner the better. For this reason the spray must reach and wet every part. It is not necessary to maintain the separate globules intact. Therefore, it is not so difficult to apply this class of sprays properly. Excessive dripping must be avoided, and the mixture of oil and water must not be allowed to run down the tree trunks, or to accumulate in the crotches of branches. In the one case the root crown may be injured; in the other the bark in the crotch may be killed and thus allow the entrance of disease spores to the heart wood. Spraying should proceed from the top downward, holding the nozzle in one place only long enough to wet that part, not until the liquid begins to run down.

Recapitulation of Spraying Directions.

To recapitulate the spraying directions for the principal mixtures in use, the following table is presented:

Paris Green and other Arsenites. Bordeaux Mixture and combinations of Bordeaux Mixture and Paris Green or other Arsenites.	Spray with a fine nozzle under heavy pressure; spray only to the point of covering the fruit or leaves with a continuous coating of fine "dew drops."
Ammoniacal Copper Carbonate. Copper Sulphate Solution. Sulphide of Potash.	When used for internal fungi, apply as directed for Paris green and Bordeaux mixture. When used against external fungi, use as directed for soap solutions and the like.
Soap Solutions. Tobacco Water. Caustic Lye Solutions.	Spray in a direct stream so as to strike with some force, using a coarser nozzle than for Paris green or the like. Avoid excessive drip and do not allow the solutions to run down the trunks.
Emulsions. Kerosene and Water. Crude Petroleum and Water.	Spray emulsions as directed for soap solutions, etc. For kerosene and water and crude petroleum and water, use a nozzle fine enough to accomplish a thorough mixing, but yet capable of projecting the liquid more as a direct stream than as a mist. Completely wet every part, but do not allow the mixtures to run down the trunks, or to accumulate in forks of branches or in deep wounds.

Purity of Materials and Proper Preparation of Mixtures.

So far, but one side of the case has been presented. There is still another important phase of the subject to discuss before all the fundamental factors leading to successful spraying results are explained. Part of these factors are beyond the control of the fruit-grower, part are within his control. The purity of the materials used and their proper preparation and combination are alluded to. These are of as fundamental importance as any of the points already mentioned. For it is obvious that unless the materials used are pure and up to standard strength, their use cannot lead to successful results, no matter how skilfully and carefully they may be applied. It will be impossible to treat of the scores of materials that have been and are used in spraying operations. Space permits only of the discussion of those substances which now constitute by far the bulk of spraying materials in general use. These will be taken up in detail and their necessary qualifications explained.*

Paris Green.

This substance, known chemically as the aceto-arsenite of copper, was first used as a remedy for chewing insects about the year 1872,† when it was recommended for use against the canker worm. A few years later, 1878 or '79, its efficacy against the codling moth was first discovered in Western New York.* Since that time its use as a poison against chewing insects has increased at an enormous rate, until at present many tons are being used for this purpose.

Paris green was first used as a pigment in painting—hence its name. As such its prime quality was its bright green color together with some insolubility in water to prevent it from being washed from painted surfaces by rains. Its chemical composition and proportion of certain chemical ingredients were therefore of secondary importance. These considerations, then, did not enter in its manufacture. With its use as a poison spray, however, its chemical composition, together with its insolubility in water, become prime requisites. A demand for a green manufactured solely for its use as an insecticide has been created, which is being met, partly at least, by manufacturers of the poison. During late years, however, there have been many complaints from users of Paris green both as to its inefficacy and its injurious action upon the foliage of trees. Upon investigation it was found that the greens prepared by different manufacturers were exceedingly variable in their composition, the results,

*For further information regarding the purity of commercial insecticides and fungicides, see Farmers' Bulletin 146, issued by the U. S. Department of Agriculture.

†Slingerland, Cornell Univ. Agr. Exp't Station, Bul. 142, p. 50.

no doubt, of so-called improvements in the method of manufacture, leading to an increased product at less expense. Paris green when pure varies both in composition and the proportions of its chemical ingredients. Add to this the variability brought about in its manufacture, and it will readily be seen how exceedingly variable and unsatisfactory a product will result.

Investigation has shown that most of the injury caused by Paris green is due to an excessive proportion of free arsenious oxid (white arsenic), either remaining as the result of careless manufacture or wilfully put in to bring up a product low in arsenic to a standard strength. Free arsenious oxid is soluble in water after a time, and when it is present in Paris green to any great extent, destroys one of the latter's most valuable qualities as an insecticide, its great insolubility in water. It is this latter quality which makes the use of Paris green possible without injury to the foliage. Free arsenious oxid is at times extremely injurious to the foliage, especially when in solution. This seems especially true in dry localities, or during dry weather having hot days followed by heavy dews or fogs at night. The arsenic seems to be more soluble under these conditions, and is dissolved by the dew and absorbed by the leaves in sufficient quantity to cause injury. More investigations of the subject are necessary, however, for at times it has been possible to use pure solutions of white arsenic without injury. But until it is known more definitely under what conditions the solutions may be used, it is safer to stick to the insoluble material.

The other complaint entered against Paris green, its ineffectiveness, was found to be the result of a reduced proportion of arsenic, the active poisonous principle of the material. It requires a certain amount of poison to kill an insect. Naturally, then, if a weaker green is applied, an amount of arsenic sufficient to cause the insect's death may not be present. This was really the first defect found in the manufactured poison, and led to legislation in some States—notably New York—stipulating that Paris green offered for sale shall consist of not less than fifty per cent. of arsenious oxid. This may have been responsible, to some extent at least, for the other count against the poison, its excessive proportion of free arsenious oxid, by leading manufacturers "to fill" a green low in combined arsenic, with free white arsenic. Such legislation, therefore, reached only half way. The law has lately been amended so as to state definitely, not only the total percentage of arsenic a sample should contain, but also the limit of arsenious oxid uncombined with copper. In California the limit of free arsenious oxid has been found to be four per cent., and that limit has been adopted in the law of that State.*

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*(Bulletin 126, California Experiment Station.)

It is extremely important, therefore, that the fruit-grower know definitely the quality of the poison a dealer proposes to sell him. Moreover, he will do well to avoid the cheaper grades of this material. It is safe to say that the majority of them are unreliable. This has been the excuse that some manufacturers have given for the low quality of their materials. "It will not pay us," they say, "to produce a good article to go into the market alongside of the cheaper grades of poison, which the growers persist in buying simply because they are cheap." This is unfortunately true to a large extent. But once the growers appreciate the folly of this penny-wise, pound-foolish policy there can be no doubt that the low-grades will "go begging" for purchasers at any price. The manufacturers have thus shown that it is possible to make a green which will meet the requirements of spraying purposes if the growers are willing to pay for it. On the other hand, unfortunately, the manufacturers are not always above suspicion. They seem willing to put out a medium-grade article and charge first-grade prices for it under the plea that it is "specially prepared." Then, too, some manufacturers, at least are preparing two grades of poison: one for sale in States where rigid laws are in force, the other for the less exacting Commonwealths. The only safe policy, therefore, lies in the enactment of laws defining the qualities of the green to be sold and providing for the inspection and analysis of all that is offered for sale. It is with the desire to acquaint farmers and fruit-growers with the true state of affairs, and with the hope of awakening them to a realization of their full needs, that these details are entered into here.

Unfortunately, there are no simple tests which will indicate whether a Paris green is up to full strength or free from the objectionable white arsenic in the uncombined state. It requires special chemical knowledge and apparatus to determine these points satisfactorily. There are, however, a few tests which the farmer can make for himself, showing whether a sample has been greatly adulterated or not. These are given below, in addition to another which can be made by any one possessing a fairly good microscope. It is recommended that a farmer perform these simple tests upon a sample of the green which he proposes to buy, and if they fulfill these to submit the sample to higher authority for examination. If the sample fail in these preliminary tests, it is unworthy of further consideration and it should then be discarded, thus saving delay in ascertaining these same facts from some other authority.

Tests for Paris Green.

1. Paris green should be a wholly dry and impalpable powder. If the sample feels gritty when rubbed between the fingers, or if the mass clings together in cakes or lumps, it is impure and unworthy of further trial.

2. *Color Tests.*—The color alone can be depended upon to determine whether a green has been wilfully adulterated or not. Pure Paris green has a decidedly bright, light emerald-green color. Any sample which presents a dull, pale or faded color is impure. By placing a small quantity in, say, a homeopathic vial, and tapping the latter gently on the bottom or sides, adulterants can often be made to separate, and can then be seen as white or light streaks or patches against the side of the vial. A pure sample will remain bright green against the glass. Woodworth, of the California Experiment Station,* has devised the following simple but effective test in connection with the color test: Place a small quantity of green, what one can easily pick up on the point of a pen knife, upon a piece of window glass which has been polished clean and dry; tilt the glass at a slight angle and gently tap the edge, just enough to cause the green to flow in a streak across the glass. If the green is of good quality, the streak will be a bright, light emerald-green; if the sample has been adulterated, the streak will have a faded, dull or whitish appearance. Any samples, therefore, which exhibit the latter have been adulterated or are of too low a grade to be used.

In connection with this test the writer has found that if great care is taken in cleaning and polishing the glass and the green is allowed to flow only gently across the surface, then by blowing strongly and quickly across the surface of the glass, from the side, in the direction of the streak, the particles of Paris green can be blown off the plate, leaving only the adulterants adhering to the glass. If they are present in large quantity they may then be seen as a dull streak by looking through the glass towards a bright window or a strong light. When the green is exceptionally pure the streak will be nearly imperceptible to the naked eye. With the aid of a compound microscope the character of the adulterants may be determined. In performing this test, great care must be exercised in blowing across the glass. The blowing must be a quick, strong puff, otherwise moisture will be condensed and the particles of green will thus be retained on the glass along with the other material.

3. *Ammonia Test.*—Pure Paris green is wholly soluble in ammonia. Place a small quantity, say a quarter or a third of a teaspoonful in a tumbler or other glass vessel, and then pour on an ounce or two of common ammonia water. If after stirring for four or five minutes the solution has assumed a deep blue color, and remains perfectly clear, and after standing no residue settles to the bottom, the green is reasonably pure at least. But if after stirring and allowing to stand an insoluble residue remains, the sample has been adulterated and should be discarded. This test will show the adulteration of the most fraudulent kind, the addition of a foreign

*Bulletin 126, California Experiment Station, p. 12.

substance merely to make up bulk and weight; and any samples exhibiting such residue may be put down as fraudulently and wilfully adulterated. Unfortunately, this test does not show the presence of uncombined arsenious oxid, which is also soluble in ammonia, and which, although it has not been considered strictly an adulterant on the ground of its poisoning qualities, nevertheless its presence in large quantity is dangerous to the foliage and ought to be known.

4. Microscope Test.—This test, unfortunately, within reach of only those in possession of a fairly good compound microscope, is one of the surest and quickest means of determining the grade of a sample of Paris green. The value of this test as a quick means of determining the fitness of samples for further examination, and as an adjunct to chemical analysis, was early insisted upon by the California Station, and wherever this test can be performed it will prove of great value and assistance, if only as a preliminary survey to a chemical analysis.

Pure Paris green under a one-quarter or one-sixth inch objective is seen to consist of clean, green spheres, wholly separate and distinct from one another; and in a pure sample these are all that can be seen. Plate VI is a reproduced photo-micrograph of a high-grade sample. A low-grade sample will have something of the appearance shown in Plate VII. The clean, green spheres are in this case mixed with particles of a crystalline structure, varying in shape and size. The appearance of such a sample indicates the addition of free arsenious oxid put in to fill or make up a green low in combined arsenic. The pure green can in this case be as distinctly seen among the particles of white arsenic under the microscope as "wheat can be distinguished from dirt that might be mixed with it."* When the white arsenic has been put in during the process of manufacture (as is sometimes done) or results from careless manipulation during manufacture, it is much more difficult to detect it. In that case the white arsenic crystals are often seen sticking to the green balls themselves, giving them, on the whole, a rather irregular outline and causing them to cling together into masses instead of remaining separate and distinct from one another.* For this reason, therefore, a chemical analysis must be resorted to in order to determine these points with certainty.

But there can be no mistake about the appearance of a wilfully adulterated sample. Plate VIII shows the appearance of such a sample under the microscope. In this case a great number of long, needle-shaped crystals are seen. They are the characteristic crystals of gypsum (calcium sulphate) and there can be no legitimate excuse whatever for their presence. These, together with the preponderance of the other irregular crystals and the almost total absence of

*Bulletin 126, California Experiment Station, p. 14.

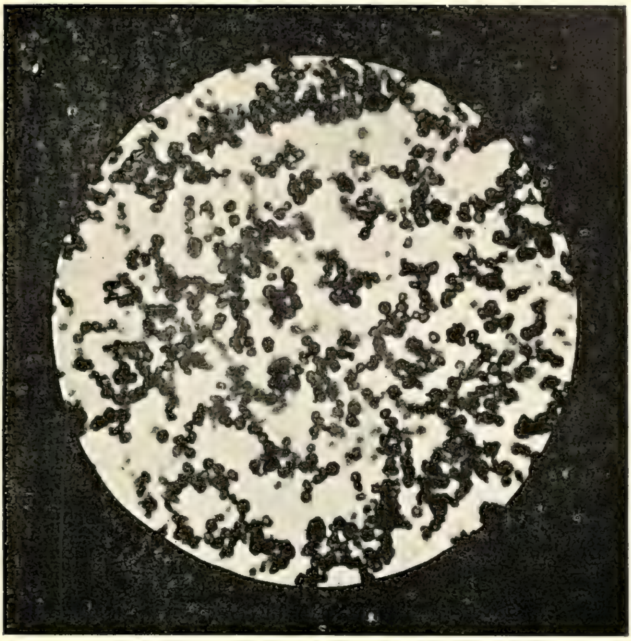


PLATE VI.
High-grade Paris green as seen under the microscope.

PLATE VII.
Low-grade Paris green as seen under the microscope.

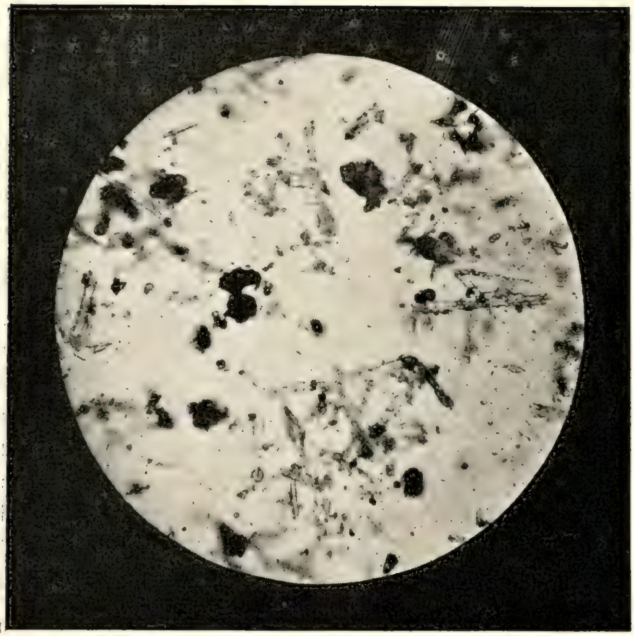


PLATE VIII.

Bogus Paris green as seen under the microscope.

the clean, green balls, brand this compound as fraudulent, and it cannot be named anything but "bogus," although the package in which it was bought was labeled "Strictly Pure Paris Green."

Requirements of a Good Paris Green.

The points which go to make a good Paris green have been summed up as follows:*

"1. It should be a wholly dry and impalpable powder. Grittiness and caking are evidences of adulteration.

"2. It should have a bright, light emerald-green color, which should not whiten or become dull in the streak left in passing a sample across a clean glass plate.

"3. It should be entirely soluble in ammonia. Any residue is an adulterant.

"4. Under the microscope it should be seen to contain only a trace of foreign matter, and should consist of clean, green spheres, wholly separate from one another. Aggregation into masses is evidence of careless manufacture.

"These are all the points which can be readily determined. In addition to the above, should be added the most important point, but one which can be determined only by a chemical analysis, viz:

"5. Paris green should contain not less than fifty per cent. of arsenious oxid, of which not more than four per cent. should be in the free state, or uncombined with copper."

Effect of the Addition of Lime.—Lime is now being added to the mixture of Paris green and water to lessen the injurious action of the uncombined arsenious oxid. This it does by combining with the soluble arsenic to form the insoluble arsenite of lime, which is fully as harmless as Paris green itself. This is true only up to a certain point, however. When the uncombined arsenic is present in large quantities the lime will do no good, and may even be harmful. It has been shown† that lime acts upon white arsenic in such a way when it is in suspension in water that the injurious action upon the foliage is greatly increased.

Objections to the Use of Paris Green.

The most serious objection to the use of Paris green as an insecticide, outside of the counts against it enumerated above, due to the shortcomings of the manufacturers, is the rapidity with which it settles in the spray tank. Paris green is a very heavy-grained substance, and therefore one requiring continuous effort to keep it in suspension. When the poison is used alone the water throughout the tank must be kept in motion. Merely creating a current around

*Bulletin 68, Illinois Experiment Station, p. 175.

†Bulletin 10, Iowa Experiment Station, p. 411; also cited by Woodworth Bulletin 126, California Experiment Station, p. 12.

the pump will not suffice. The problem of sufficient agitation is thus rendered doubly important, for without more satisfactory agitating devices than those now in general use, it is extremely difficult to secure a uniform distribution of the poison. And without a uniform distribution of the poison perfectly satisfactory results are impossible: the first portion sprayed out of the tank will be too weak to do effective work, while the last portion will be strong enough to injure the leaves, or in case the agitator is very poor the bulk of the poison will remain on the bottom and sides of the spray tank.

When Paris green is used in combination with Bordeaux mixture to form a combined insecticide and fungicide, the rapid-settling objection to this otherwise valuable poison is very largely overcome. The grains of the green become mixed with the floccular precipitate of the Bordeaux mixture, and settle slowly with it. A few of the heavier or larger grains go straight to the bottom, as they all do when the poison is used alone, but the great majority remain in suspension with the Bordeaux mixture.

Substitutes for Paris Green.

The many failures resulting from the use of impure Paris green, and the prevalence of the low-grade qualities of the poison put upon the market, have led to the introduction of other insecticidal poisons for use as substitutes. These are practically all arsenites, and therefore, like Paris green, have arsenic as their active poisonous principle. These poisons seem peculiarly virulent to insect life, and this fact, together with their usual insolubility in water, make them the most valuable class of compounds for this purpose. Some of these, notably the arsenite of lime (arsenic, sal-soda and lime mixture), the arsenate and arsenite of lead, are steadily growing in favor, especially when home-made. These have been successfully used by a number of growers and unless manufacturers of Paris green are more careful to supply a reliable and satisfactory article, it is safe to say these substitutes will largely supplant Paris green in the future. The home-made mixtures possess the additional advantage of being much lighter grained than Paris green, and therefore they can be kept in suspension very much more easily. This is especially true of the arsenate of lead, which, when freshly prepared, forms a milky precipitate which will remain in suspension for a long time without agitation. In addition, the lead compounds may be used very much stronger without danger to the foliage, a fact which makes them particularly valuable for use on the foliage of the stone-fruits—notably peaches and plums—which are notoriously sensitive to sprays of all kinds.

The chief argument urged against the use of home-made poisons is the trouble and labor of preparing them, the advantage of Paris green being that it is ready to use just as it comes from the store. But the addition of lime when using the latter alone has come to be generally recommended. This really destroys the ready-to-use argument in favor of Paris green. It is only a step further to prepare the home-made poison. Why not take this step? Thus preparing a mixture of known composition and avoiding all the uncertainties of the commercially prepared article.

Several commercial substitutes for Paris green have been introduced, most of them as arsenoids, or arsenates of different derivatives. In general, it may be said of these that they are all open to the same objectionable uncertainties that Paris green is, and they may thus be put in the same catagory. The freshly prepared home-made mixtures are very much better as far as remaining in suspension is concerned; for after the precipitate is dried it cannot be reduced to a state of division equal to the floccules produced in the liquid. For this reason alone, then, the home-made preparations are preferable.

A number of preparations have been introduced under different patented trade names. Experience and examination have shown few, if any, of these possessed of exceptional virtues over the "straight" goods. As a rule, therefore, it is safest for the fruit-grower to give these special preparations a wide berth, unless their advertised recommendations are supported by the strongest evidences of chemical examination, or the strictest practical trial that can possibly be given.

Bordeaux Mixture.

This compound, discovered accidentally in France about twenty years ago, has become perhaps the most widely used spray mixture of any kind. It is by far the most effective fungicide known, as many trials in all parts of the world have demonstrated. It consists essentially of copper hydroxid precipitated from a solution of copper sulphate by caustic lime (calcium hydroxid). The copper is the active principle of the fungicide; that is, the effectiveness of the mixture in destroying a fungous disease, or preventing its development, is due wholly to the presence of the copper. Lime has been shown to possess, at best, only very weak fungicidal properties. The lime used in the preparation of Bordeaux mixture may, therefore, be considered as merely an agent to convert the copper sulphate into a less injurious copper compound. In the form of the sulphate, it is perhaps a more effective fungicide, but it is then so injurious to the foliage of growing trees and plants, unless used too dilute to be effective, that its conversion into an insoluble and therefore less injurious form, is necessary. It is for this purpose that the lime milk is used.

The materials composing Bordeaux mixture are both staple market articles, and in commerce are pure enough for all practical purposes. The sulphate is marketed both as large and small crystals, but for spraying purposes the small crystals are just as good as the large. The only adulteration which need possibly be feared is the admixture of iron sulphate—copperas. So far as known, however, copper sulphate adulterated to any serious extent has never been found in the regular market.

Lime is more variable. In some localities it is unavoidably prepared from a very poor class of rock. When such lime has to be used in making Bordeaux mixture more has to be put in than when a lime of good quality can be obtained. But the quantity of lime should never be gauged by measure alone, for it is so essential that enough be used "to neutralize" all of the copper sulphate, that the mixture should be tested with either of the two simple tests at command to determine this point with certainty. A solution of potassium ferrocyanide, yellow prussiate of potash (1 oz. dissolved in about a pint of water), is perhaps the most convenient test for determining the presence of sufficient lime. A few drops of this solution added to a mixture containing insufficient lime will produce a reddish brown discoloration, while when sufficient lime has been added no discoloration will result. In making this test it is best to dip out a small quantity in a white saucer or shallow dish. Any slight discoloration will then be readily seen against the white dish, which would not be visible if the test were made by pouring the ferryocyanide solution into the spray tank. The mixture should be thoroughly stirred before applying the test, and in order to be certain that it is, it is also best to make two tests, giving a vigorous stirring between them. The writer has sometimes found the second test to be different from the first. When the two are alike it is safe to presume that enough lime has been used. In using the ferrocyanide it must not be forgotten that it is a virulent poison. The utmost care is therefore necessary in having the bottle properly labeled and out of reach of children and careless persons. When large quantities of stock solutions are made up one test will suffice for the whole amount on hand. That is, the one test will indicate the proper proportion of lime to use for the total quantities of stock solutions prepared. Another excellent method is "to standardize" the lime milk with the copper sulphate solution by making a small quantity of test mixture. The method of making this test and standardizing as given by the writer in Bulletin 68 of the Illinois Experiment Station is as follows:

"Make up the stock solution of copper sulphate as usual, one pound per gallon of water. Slake the lime, making of it a thin paste. Now take one pint of the copper sulphate stock solution, dilute to about a gallon, and add to that small measured quantities of the

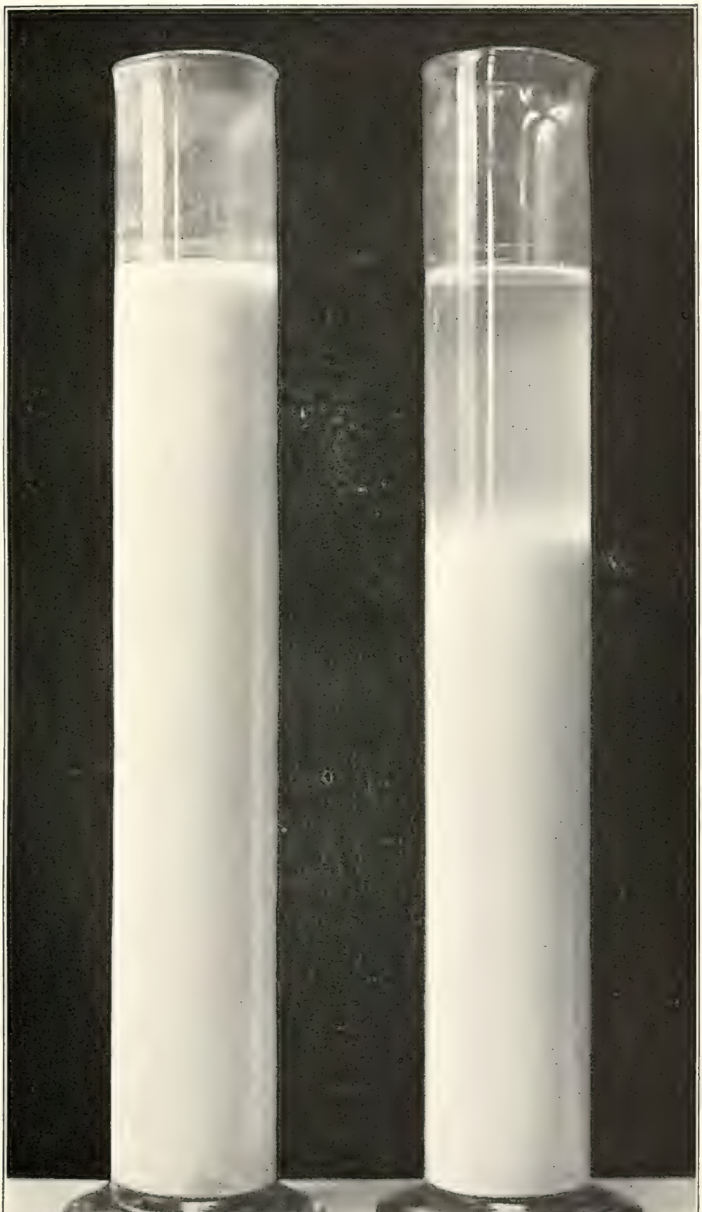


PLATE IX.

Properly and improperly made Bordeaux Mixture, after settling twenty minutes.
(From Bulletin 68 of the Ill. Exp't. Station.)

PLATE X.

Properly and improperly made Bordeaux Mixture, after settling one hour.

(From Bulletin 68 of the Ill. Exp't. Station.)

lime, testing after each addition, until the sulphate has all been neutralized. From the quantity of lime thus used the necessary dilution can be calculated to make the lime milk any desired strength. The proportion of water necessary to make the proper dilution will be equal to the difference between the required strength and the quantity of lime milk used to neutralize the sulphate, expressed in fractions of that strength. Thus, if one-half pint is used in the neutralization, and if it is desired to have the lime of the same strength as the sulphate solution, it will require one-half pint of water for each one-half pint of lime milk; therefore, the total quantity of the latter will simply have to be doubled, by adding an equal quantity of water. If only one-quarter pint was necessary to accomplish the neutralization, the total would have to be quadrupled, or three times the quantity of water added. In large-scale operations this standardizing of the lime milk will be found very advantageous, especially where the mixing is not all done by the same man. In this case, the standardizing can be done by the foreman, or head operator, and then the spray crews have simple, straight measuring to do."

Another very simple test for determining the sufficiency of lime is the so-called knife-blade test. This test consists of simply placing the end of a bright knife-blade, key or other steel object in the mixture. If too little lime has been used in the mixture the bright steel will be coated with metallic copper, or copper-plated, while if enough lime is present to combine with all the copper sulphate no such plating will take place. The making of these tests are important; for it must be emphasized that there must be no free copper sulphate in the completed Bordeaux mixture. In order to be absolutely certain of this it is best to use an excess of lime milk, which does no harm. In fact, for use on tender foliage, such as peaches and Japanese plums, it is necessary to prepare the mixture with a large excess of lime milk in order to avoid injury.

Bordeaux mixture belongs to the class of spray washes which consist of insoluble substances in suspension in water. All the precautions, then, mentioned before regarding this class of mixtures are applicable and must be observed. But in this case a good deal of the difficulty in maintaining the compound in suspension may be avoided in the preparation of the fungicide. That is, it is possible so to mix the two ingredients that the resulting precipitate will settle slowly, and may thus be kept in suspension with a minimum effort of agitation. Plates IX and X exhibit the effects of different methods of preparing Bordeaux. The photographs were taken after allowing the mixtures to settle twenty minutes and one hour respectively. The mixture in the left-hand cylinder was prepared by mixing dilute copper sulphate solution and dilute lime milk together. The right-hand mixture was made by mixing the concentrated solu-

tions together, and then diluting. That is, the diluting was done before mixing in one case; in the other, after mixing. The vast differences in the rates of settling are well shown by the pictures. In the properly prepared mixture there was practically no settling at the end of twenty minutes, while the improper preparation gave a mixture which settled approximately one third of the total column in the same time, as shown by the clear liquid above the sediment. At the end of one hour the properly prepared Bordeaux showed less than an inch of clear liquid on top, indicating only a slight settling; the improperly prepared showed nearly two-thirds of the column clear. The importance of these differences in practice are at once apparent. A mixture such as that in the left-hand cylinder does not need continuous agitation; simply stirring thoroughly every five or ten minutes, or a few turns of a separate agitator while moving from one tree to another, will be amply sufficient. For the mixture prepared in the other way, continuous agitation would be necessary to insure a uniform distribution of the remedy.

Moreover, the compound formed when the concentrated solutions are mixed is without doubt different in its chemical make-up, and in all probability has not the same fungicidal value as has that made with the diluted solutions. Just how this is, however, has not been fully worked out. From the standpoint of its physical properties alone, the heavy flaky—"curdled"—precipitate is less effective as a fungicide. In the first place it cannot be so easily applied; in the second, the flakes do not adhere so well, and in the third the coating of the mixture will not be as complete as when the precipitate is finer grained.

Bordeaux mixture should never be made with hot solutions. This applies especially where the copper sulphate is dissolved in hot water, or when freshly slaked lime is used. The writer has found that the mixture made with cold solutions is even very much better than when only moderately warm. Thus, for instance, quite a marked difference was observed when the solutions were mixed at 60 degrees (F.) and at 80 degrees (F.). The 60-degree solutions gave a mixture with very much better "staying-up" qualities than the 80-degree. When the hot solutions are mixed a different precipitate is formed, the dehydrated or anhydrous black copper oxid. This precipitate settles very rapidly, and upon that score alone, is to be avoided.

Nothing but fresh or quick lime should be used. Air-slaked lime is very unsatisfactory and should never be used. It yields a mixture which settles rapidly, and which is, moreover, mixed with heavier particles of carbonate of lime. The compound is, therefore, quite different from the properly prepared Bordeaux mixture. The lime should be carefully slaked by adding to it just enough water to keep it moistened and prevent it from "burning." If the slaking is care-

fully done and the lime is of good quality, a smooth paste with very little grit will be formed. The lime paste may be made in quantity and kept during the entire season if care is used to keep it covered with water or means used to prevent it from drying out. If it is allowed to become dry, it will not work up smooth, and a lumpy, gritty milk will result.

The question has often been asked whether it makes any difference whether the lime or the sulphate is first put into the tank; that is, if it makes any difference whether the lime is poured into the copper sulphate or vice versa. Investigations at the Vermont Station* have shown that Bordeaux mixture prepared by pouring dilute copper sulphate solution into dilute lime milk, stirring vigorously all the while, or by pouring the solutions together into the tank, remains in suspension better than that made by pouring the lime into the sulphate solution. The results of the work done at that station tend to show also that the Bordeaux so prepared possessed better fungicidal properties when used upon potatoes.

Bordeaux mixture should be used only while fresh. If allowed to stand for some time—say from one day to another—the precipitate changes in such a way that it will not remain long in suspension. This increases the difficulties of agitation. It is probable also that the fungicidal value of old Bordeaux mixture is different from that freshly prepared. But the rapid settling seems to be the most serious objection. Lodeman† cites a case in his experience where Bordeaux mixture several weeks old was successfully used on apple trees by using extra precaution to keep the precipitate in suspension. All other experience seems to indicate, however, that the freshly prepared mixture is by far the most effective.

Mixing Outfits.

Where a large quantity of Bordeaux mixture is prepared a special mixing outfit will greatly facilitate the work and will be found well worth the expense of constructing it.

The most successful of these outfits in operation consist of a system of elevated tanks, so placed that the solutions may be run into a third tank to form the mixture, and from the last into the spray tank. For this purpose a series of tiers of three platforms, each higher than the other, should be constructed. On the top one should be placed the barrels holding the stock solution of copper sulphate and lime milk. On the second platform should be placed two diluting tanks, each with a capacity of a little more than one-half the total quantity of Bordeaux to be prepared at one time. On the lowest platform the mixing tank is to be placed. This tank should be large enough to hold a full charge of mixture for the size of tanks used.

*Vermont Agricultural Experiment Station, 9th Annual Report, 1895, pp. 88-98.
†The Spraying of Plants, p. 132.

If water under pressure is available, all the better; if not, a pump throwing at least a two and one-half inch stream should be provided to raise the water to the highest tanks. In using such a system the mode of procedure would be somewhat as follows: The lime is first slaked, best perhaps on the ground in a box for the purpose. In the upper barrels the stock solutions are made to the required strength. From these the proper quantities are run into the diluting tanks below. Then water is pumped in to dilute the two solutions each to about one-half the total quantity to be made. After thorough stirring, these are in turn run into the mixing tank through cocks so placed that the streams of copper sulphate and lime come together as they fall into the tank. After thorough stirring and testing the mixture is ready to be run into the spray tank. Of course, the lowest tank should be placed somewhat higher than the spray tank to allow the completed mixture to be conveniently run in.*

Before closing this discussion of the preparation and use of Bordeaux mixture, it is well to call attention to a few minor details, which, though apparently of little consequence, go far to lessen the drudgery of spray work, and to that extent at least assist in securing good results.

In the first place, the lime milk should be carefully strained. The writer fully realizes that it is no easy task to strain large quantities of milk of lime; but he is at the same time convinced that some considerable effort in this direction will be found well expended and may save much vexatious clogging of the nozzles. The strainer should have not fewer than twenty meshes to the inch, and should be of brass wire. (Iron would be quickly corroded by the copper.) The strainer should also be made as large as possible—large enough to fit over the entire head of an open barrel. If the straining surface is thus made large, the straining will be comparatively easy and rapid. For extra safety the completed mixture may be strained as it is run into the tank.

When the spray tanks, barrels, pump and apparatus are to stand unused for a time, they should be thoroughly cleaned by washing and running through a few gallons of cheap vinegar to remove all clinging particles of Bordeaux mixture. If these particles are allowed to remain and dry, they form scales which become loosened the next time the apparatus is used, and cause most vexatious and discouraging delays.

Ammoniacal Copper Carbonate Solution.

This spraying compound ranks very high as a fungicide, being surpassed in effectiveness only by Bordeaux mixture. It is particularly valuable for use when late applications have to be made, where the

*For a more detailed account of a mixing outfit successfully used in a large apple orchard, see Bulletin 68 of the Illinois Experiment Station, page 181.

stain left by Bordeaux mixture would be objectionable. The solution when properly prepared is perfectly clear and of a very light blue color, which, however, is practically invisible after it has dried upon the leaves or fruit. For the very late spraying of peaches and plums against the brown ripe rot it is especially valuable.

The materials for preparing the solution are copper carbonate powder and commercial ammonia. The first needs no comment, for it has not been found adulterated so far as known. If one cares to take the trouble, however, the powder can be prepared at home at about one-third the cost of the commercial article. The following method of preparing the chemical has been given by Chester in the Annual Report of U. S. Com. Agric. for 1890.*

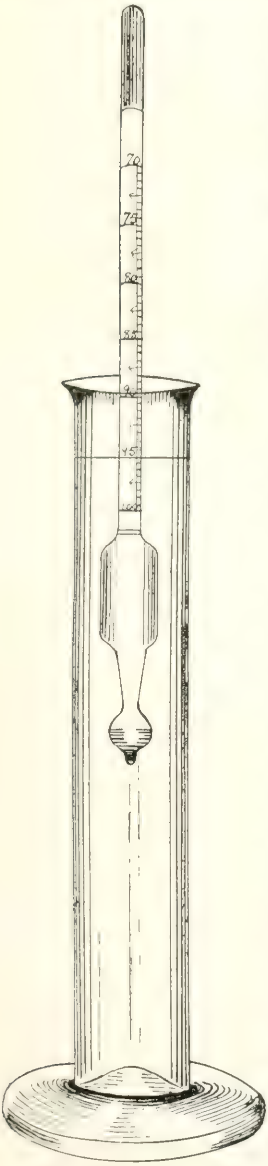


FIG. 4.†

"Dissolve in a barrel twenty-five pounds of copper sulphate in hot water. In another barrel dissolve thirty pounds of sal-soda. Allow both solutions to cool; then slowly pour the solution of sal-soda into the copper sulphate solution, stirring the same. Fill the barrel with water and allow the precipitate of copper carbonate to settle. Upon the following day siphon off the clear supernatant liquid, which contains most of the injurious sodium sulphate in solution. Fill the barrel again with water, and stir the precipitate vigorously into suspension; again allow the precipitate to settle, and again on the following day draw off the clear liquid. The operation washes the carbonate free of most of the sodium sulphate which contaminates it. Make a filter of stout muslin by tacking the same to a square wooden frame which will just fit over the open top of the second barrel, letting the muslin hang down loosely so as to form a sack; through this filter pass the precipitate, so as to drain off the excess of water, and as the filter fills, remove the precipitate and allow it to dry in the air, when it is ready for use. The operation is not troublesome, and can be carried on in connection with other work. .... By using the above amounts of material there will be formed a trifle over twelve pounds of copper carbonate."

*Cited by Lodeman, "The Spraying of Plants," p. 137.
†From Bulletin 68 of the Illinois Experiment Station.

The ammonia water used for preparing the copper carbonate solution should be of the strength designated as "26 degrees Beaume," the ordinary commercial product. Of adulteration, there is little to fear. Sometimes, however, it is weak, owing to the escape of the gas from the solution (it is simply a solution of ammonia gas in water) when the vessels containing it are not tightly closed. When up to full strength the 26-degree ammonia contains about 25 per cent. of the gas, and it is upon this strength that the quantity recommended in the formula for preparing the solution is based. It should be borne in mind, however, that no more ammonia should be used than is actually necessary to dissolve the copper carbonate; the smaller the quantity, the better. Ammonia has an extremely caustic action upon the leaves and when used too strong serious injury is sure to follow. For this reason it is safest for those who make use of the copper carbonate solution to any great extent to provide themselves with a "specific gravity spindle" for testing the ammonia they intend to use. Fig. 4 represents such an instrument in use. A tall cylinder, such as shown in the drawing, is filled with the ammonia water to be tested. The spindle is then allowed to float in the liquid. The depth to which the bulb will sink will depend upon the density of the liquid. The upper stem of the spindle is graduated to show the specific gravities indicated by the different depths to which the bulb sinks in the liquid to be tested. The figure at the surface indicates the specific gravity, or relative density as compared with water, of the ammonia water being tested. The specific gravity in turn indicates the percentage of ammonia, which can be found by reference to the appended table. For example, if the spindle indicates a specific gravity of .902, by reference to the column "specific gravity" the figure opposite in the "Per cent. of Ammonia" column is found to be 24.94, thus indicating that the ammonia water is practically up to strength. If the ammonia is stronger, less will be required to accomplish the solution; if weaker, more must be used. With this test, the fruit grower is enabled to determine just what strength of ammonia he has to deal with, and thus all dangerous guess-work can be avoided.

*Table Showing Percentages of Ammonia in Solutions of the Gas in Water, as Indicated by their Specific Gravities.

Specific gravity.	Per cent. of ammonia.	Specific gravity.	Per cent. of ammonia.	Specific gravity.	Per cent. of ammonia.
.960	9.51	.932	16.81	.904	24.39
.958	10.03	.930	17.34	.902	24.94
.956	10.54	.928	17.86	.900	25.50
.954	11.07	.926	18.42	.898	26.05
.952	11.59	.924	18.93	.896	26.60
.950	12.10	.922	19.67	.894	27.15
.948	12.62	.920	20.01	.892	27.70
.946	13.13	.918	20.56	.890	28.26
.944	13.65	.916	21.09	.888	28.86
.942	14.17	.914	21.63	.886	29.46
.940	14.69	.912	22.19	.884	30.14
.938	15.21	.910	22.74	.882	30.83
.936	15.74	.908	23.29		
.934	16.27	.906	23.83		

†Beaume 16° indicates .960 sp. gr.
Beaume 20° indicates .960 sp. gr.
Beaume 22° indicates .924 sp. gr.
Beaume 24° indicates .913 sp. gr.
Beaume 26° indicates .901 sp. gr.

If possible, nothing but rain water should be used in diluting the ammonia for the solution. When ammonia is added to well or spring water, a heavy floccular precipitate is apt to be formed, which must not be mistaken for undissolved particles of copper carbonate. The latter are easily distinguishable, being light greenish blue in color and somewhat flaky, while the precipitate from the water is formed in rather large, dark floccules. These floccules do no harm. The danger lies in mistaking them for the undissolved carbonate and adding enough ammonia to bring them into solution, which requires far more than plants will endure.

The solution must be made in wooden or earthen vessels and wooden stirring implements should be used. Iron vessels would be soon corroded by the action of the copper.

*Compiled from the Table of Lunge und Wernik, cited by Caldwell: "Elements of Chemical Analysis," page 173.
†Lodeman: "The Spraying of Plants," page 116.

FORMULAS.*

Mixture.	Quantities for 5 gallons of mixture.	Quantities for 50 gallons of mixture.	Quantities for 100 gallons of mixture.	To be Used Against	Method of Preparation.
Paris Green, ... Fresh Lime, ... Water, ...	½ oz. ½ oz. 5 gals.	4 ozs. 4 ozs. 50 gals.	½ lb. ½ lb. 100 gals.	All chewing insects—codling moth, canker worm, curculio, currant worm, leaf skeletonizer, potato beetle and the like.	Make a thin paste of the lime by slaking it with water; strain; place lime paste and Paris green in a bottle or jug and shake vigorously until thoroughly mixed; then add to full quantity of water. For potato beetles the proportion of poison may be increased to 1 lb. to 125 gallons of water.
Scheele's Green or Copper Arsenate, ... Fresh Lime, ... Water, ...	¾ oz. ¾ oz. 5 gals.	6 ozs. 6 ozs. 50 gals.	¾ lbs. ¾ lbs. 100 gals.	All chewing insects, ...	Proceed as for Paris green.
Arsenite of Lime: White Arsenic, ... Sal Soda, ... Fresh Lime, ... Water to make, ...	¼ oz. 1 oz. ½ lb. 5 gals.	2 ozs. ½ lb. 4 lbs. 50 gals.	¼ lb. 1 lb. 8 lbs. 100 gals.	All chewing insects, ...	Boil arsenic and soda in small quantity of water in an iron pot not used for other purposes, until all the arsenic is dissolved. Slake the lime making a thin paste of it; strain and add to full quantity of water; then add soda and arsenic solution, and stir for a few minutes.
Arsenate of Lead: Lead Acteate, ... Soda Arsenate, ... Water, ...	1¼ ozs. ½ oz. 5 gals.	12½ ozs. 5 ozs. 50 gals.	1¾ lbs. 11 ozs. 100 gals.	All chewing insects, ...	Pulverize and dissolve the acetate and arsenic separately in small quantities of water; add separately to full quantity of water, and stir for a few minutes. This is especially valuable on tender foliage, such as peach and plum, and can be used stronger with impunity.

*Prepared for Circular 39 of the Illinois Exp't Station, and the Annual Report of the Illinois State Horticultural Society for 1901.

FORMULAS—*Continued.*

Mixture.	Quantities for 5 gallons of mixture.	Quantities for 50 gallons of mixture.	Quantities for 100 gallons of mixture.	To be Used Against	Method of Preparation.
Kerosene Emulsion: Kerosene, ... Whale Oil Soap, ... Or Soft Soap, ... Water, ...	 2 gals. ½ lb. 1 qt. 1 gal.	Stock emulsion to be diluted as directed below.			Slice the soap finely and dissolve in the water by boiling; add the boiling solution (away from the fire) to the kerosene, and stir or churn violently for from five to eight minutes, until the mixture assumes a creamy consistency. If a spray pump is at hand, pump the mixture back upon itself with considerable force for about five minutes. If no soft soap or whale oil soap is at hand, use 1 lb. common soap dissolved in the boiling water.
Kerosene Emulsion, ... Water to make, ...	3 qts. 5 gals.	7½ gals. 50 gals.	15 gals. 100 gals.	Scale insects, larger plant bugs, larvae and beetles.	Use rain water in the dilutions, if possible. If hard water is used "break" it with lye (1¼ lb. to 50 gallons) before using.
Kerosene Emulsion, ... Water to make, ...	2½ pts. 5 gals.	3¼ gals. 50 gals.	6¼ gals. 100 gals.	Plant-lice and soft-bodied insects.	Prepare as for scale insects.
Kerosene-Milk Emulsion: Kerosene, ... Sour Milk, ...	 2 gals. 1 gal.	Use as directed for the kerosene-soap emulsion.			No heating is necessary in this case. Thorough churning or pumping as directed above will effect the emulsion. This emulsion is valuable where hard water must be used, no breaking with lye being necessary.
Bordeaux Mixture, ... Copper Sulphate, ... Fresh Lime, ... Water, ...	 6½ ozs. 7 ozs. 5 gals.	 4 lbs. 4 lbs. 50 gals.	 8 lbs. 8 lbs. 100 gals.	All fungi, especially internal fungi.	Dissolve copper sulphate in small quantity of water; slake the lime carefully, making a thin milk of it. Now dilute the two solutions each to about half the total quantity of mixture to be made; mix them together and stir vigorously for a few minutes. Test with yellow prussiate of potash solution, or knife-blade, and add more lime if necessary.

FORMULAS—*Continued.*

Mixture.	Quantities for 5 gallons of mixture.	Quantities for 50 gallons of mixture.	Quantities for 100 gallons of mixture.	To be Used Against	Method of Preparation.
Ammoniacal Copper Carbonate: Copper Carbonate, ... Ammonia 26°, ... Water to make, ...	½ oz. ½ pt. 5 gals.	5 ozs. 3 pts. 50 gals.	10 ozs. 6 pts. 100 gals.	All fungi.	Make a thin paste of the carbonate with water. Dilute one-third the ammonia seven or eight times; pour on carbonate; stir vigorously and allow to settle; pour off clear liquid. Dilute another one-third of the ammonia five or six times and add to residue left; stir and allow to settle as before; pour off clear liquid. Dilute the rest of the ammonia two or three times and add to the residue. If the ammonia is full strength this should all enter into solution; if not, more ammonia may be added until the carbonate is entirely dissolved. Rain water should be used in diluting the ammonia. The solution should be clear. Dilute to spraying strength.
Sulphide of Potash, ... Water, ...	2 ozs. 5 gals.	20 ozs. 50 gals.	2½ lbs. 100 gals.	Fungi which grow with their mycelium exposed: mildews of gooseberry and rose, and powdery mildew of grape.	Dissolve the sulphide in warm water and dilute to spraying strength. The solution loses its strength quite rapidly and should be used only while fresh.
Bordeaux and Arsenites Combined: Bordeaux Mixture, ... Paris Green, ... or Scheele's Green, ... or Arsenate of Lead, ...	Usual strength as given above.			Fungi and chewing insects.	If Paris green or Scheele's green is used, prepare the Bordeaux mixture as directed above. Wet the powder by shaking in a bottle and add to the completed mixture. Stir vigorously before using. If arsenate of lime is used, add enough additional milk of lime to the Bordeaux to make the arsenite, then add the arsenic and soda. For arsenate of lead, dissolve the lead acetate and soda arsenate as above directed and add these solutions separately to the water which is used to dilute the milk of lime; stir well and add lime; then add diluted copper sulphate solution and stir.

INSECTS INJURIOUS TO CUCURBITACEOUS PLANTS.

BY H. A. SURFACE, *Professor of Zoology, Penna. State College.*

CUCURBITACEOUS PLANTS.

By the above term is meant those plants that belong to the botanical family *Cucurbitaceæ*. Although they are all vining plants, one could not give them the common name of "The Vining Plants," because such a term would apply as well to sweet potatoes, grapes, etc. Belonging to this family are the following: Watermelon and citron, muskmelon or cantaloupe, cucumber, squash, gourd, cashaw, pumpkin,, etc.

The citron is but a variety of watermelon that is used for preserving, as regular citrons of commerce are preserved. Muskmellons and cantaloupes are identical, although some persons have attempted to indicate differences.

INSECTS.

GENERAL REMARKS ON INSECTS.

Since the insects that attack one species of these plants are found more or less injurious to all of the family, we shall not make a separate list of species of insects for each kind of plant, but shall discuss them in their consecutive entomological order. We refer for the practical measures of each to the separate discussions of preventives and remedies given in the latter part of the bulletin.

CLASSIFICATION.

In order to understand the principles of the classifications, life histories, and remedies given later, it is necessary to bear in mind the following fundamental facts concerning insects:

The class of insects (*Insecta*) is divided into large groups called Orders, and the latter are in turn divided into smaller groups, each called a Family. Families contain yet smaller groups called Genera and the final division of the latter is Species. The scientific name of an insect is the name of its genus and species written in the order here indicated. The classification of an insect is its order, family, genus and species. In the following pages we have expressed the classifi-

cations of the insects to be treated by naming the order and family and giving the scientific name of each.

Orders and families are founded upon certain common important structures, the more potent and general of which characterize all insects belonging to the major group. There are nineteen orders known to modern entomologists, but the insects treated in this article represent only five of these.

STAGES IN LIFE HISTORY OF INSECTS.

Insects undergo transformations called metamorphoses. In their life cycle they exist in certain forms called stages. Those treated in this bulletin have either three or four stages, according to their kind of metamorphosis. It may be "Incomplete," in which the insect has but three stages: (1) The egg, (2) nymph or immature, and (3) imago or adult. (See Fig. 1.) In this group the young resemble the adult in form and generally in habits, lacking only the wings. There is no worm-like existence and no pupal or quiescent stage. The squash bugs and grasshoppers are good examples of insects with incomplete metamorphosis. The young are called nymphs.

The representatives of the next group, or those with complete metamorphosis, pass through four stages: (1) The egg, (2) the larva, or worm-like stage, (3) the pupa or resting stage, and (4) the imago, adult or mature insect. (See Fig. 2.) The young are called "larvæ" and do not at all resemble the adults. They are popularly known as "worms," but this common name should not be given them, since worms are independent creatures that do not transform into any other form or stage. (Example, the earthworm).

Insects grow only in the nymph or larval stages. They do not become larger after having once reached the adult or winged stage. They live in the latter condition but a few days or weeks, mate, lay their eggs and then die.

Some adult insects do not eat; others, like the butterflies, only sip a little nectar and do not have feeding habits similar to their young. Others, like the squash bugs and cucumber beetles, eat the same kind of food as do their nymphs or larvæ.

The feeding habits of insects is a fundamental feature in applying insecticides. Some have biting mouth-parts with strong jaws and chew the leaves or tissues of the plant. (Examples, caterpillars, beetles, etc.) These insects that chew can nearly always be killed by poisons, which are to be taken internally, among which the arsenites are prominent, and Paris green is the most valuable. (See Insecticides, A.) The insects that do not chew their food have piercing mouth-parts, as has the squash bug. (See Fig. 3.) As they are suctorial and do not suck before the bill is inserted, they are not affected by poison lying on the leaf. They must be killed by contact applica-

tions (See Insecticides, B.), which kill by entering the breathing pores, but not the mouth.

THE SPECIES OF INSECTS.

ORDER PHYSOPODA: Family Thripdæ: Thrips. (Fig. 4.)

Tobacco Thrips or Onion Thrips (*Thrips tabaci*).

The Thrips are among the most minute of insects. Their mouth-parts are fitted partially for sucking and partially for biting, but mostly the former. They do not eat away the tissues of the plant, but pierce the leaves and cause small white specks which may become so abundant as to give the plant a grayish appearance. These insects are from one-sixteenth to one-fortieth of an inch long and about one-fifth as wide. They are dark in color and have four very minute wings fringed with long hairs which increase their surface area and flying capacity. When disturbed they suddenly disappear by jumps or short flight.

This species has been reported feeding on sixteen species of plants, besides on melons, squash and cucumbers; mostly on onions and cabbage, where they are at times very destructive.

Their habit of sudden jumping flight gives the key to the remedy for them, which is Mechanical Device No. 3. They will fly down the wind and be carried against the tarred cloth or board held in their path of flight to the leeward. They can of course be killed by contact applications; also by Mechanical Device No. 3 and by insecticides 6 to 12.

ORDER HEMIPTERA: The True Bugs, Plant Lice, Scale Insects, Etc.

FAMILY COREIDÆ: The Squash Bugs. (Fig. 5.)

The Squash Bug or "Stink Bug" (*Anasa tristis*).

The squash bug is about five-eighths of an inch long and one-fourth of an inch wide, with antennæ half the length of the body. The head is dusky, nearly black; thorax or part to which the wings are attached, dark brown; scutellum or triangular piece between the wings, dusky; sides of abdomen or posterior part banded with six yellowish bands; upper wings dark and brown or grayish at basal half and sooty black toward the tips, which are thinner; the under wings are smaller and very thin and gauze-like toward the base and

dark toward the tips. The legs are long and slender, the hinder pair measuring half of an inch in length. The suctorial beak is very long (one-fourth inch), sharp and slender, and reaches back on the ventral side to the base of the hinder pair of legs. (See the upper specimens of Fig. 5.)

The nymphs are much broader in proportion to length than are the adults. The adults of these insects fly readily by day and are not attracted to lamp traps at night.

This common and well-known insect is the most destructive of the pests infecting Cuburbits toward the middle and latter part of the summer. It appears about the last of June and is found on the vines or fruit until after frost comes. The first one found by us was on a plant just about sprouted, on the 15th of June. They feed on all Cucurbits, by sucking out the juice of the plant. According to the habit of many other bugs, they inject a poisonous saliva into the plant and this turns the leaves dark in spots and causes them to wither, crumple and soon turn brown. (Fig. 6.)

They are social insects, living in groups under the crumpled leaves and under or sometimes upon the large leaves that lie on the ground. (Fig. 7.) The first mating occurs in the latter part of June and the first eggs are deposited in the early part of July. The eggs are large, oval and at first are white and adhesive. They gradually become cream colored, reddish brown, and wine red; later they become bronze red, and shortly before hatching are nearly black. They are deposited in diagonal rows in irregular-shaped patches, generally beneath the leaves, but sometimes above. (Fig. 8.) The distance between them is equal to one-half the width of the tip of the abdomen of the female. They are very conspicuous and can readily be detected for the remedies given below. The number in a patch varies from a very few to over fifty. They hatch in from ten to sixteen days, according to temperature, hatching sooner when the weather is warmer. They are so plainly seen that they can readily be destroyed. They adhere too firmly to be easily picked off, and we have found that they can be painted with a touch of pitch and killed. Painting with pure kerosene does not always prevent their hatching.

The very young bugs are very brightly colored. Their bodies are light green and their legs and antennæ are bright red. Within an hour the appendages turn dark and become black. The young bugs live in groups (Fig 9) and moult several times. They finally obtain wing pads and the next moult they have wings and are adult. After the final moult they are at first white, but in a few minutes become dingy brown, then darker, and in a few hours grayish. Soon they pair and the females afterwards lay from one hundred and fifty to three hundred eggs. A second laying of eggs often ensues and thus the second brood may appear. They have the same appearance and

habits as the first brood. In the northern part of the United States there is but one brood. When the weather is cool they go under cover for protection, and come out into the sunshine to be warmed. (Fig. 10.) At night they seek the cover of a leaf, the under side of a board, etc. (See Fig. 44.) This habit leads them to their destruction where board traps are used. (See Mechanical Device No. 4.)

In the fall of the year the insects are quite likely to collect on the green fruits of the vine and suck juices from them after they can no longer derive any from the leaves. This is the time that they should especially be killed by kerosene spray or sprinkling to prevent their scattering and living through the winter to become the pregenitors of of next year's pests.

As the broods are not sharply separated, but some individuals lay early and others lay later and the laying and hatching continues throughout the season, all stages can be found at one time, and there is the appearance of continuous breeding. (Fig. 11.)

The winter is passed in hibernation in the adult stage, sometimes far away from the places where the infested plants grew. They hibernate in woods, along fences, in rubbish, under boards, especially in lumber piles, in grass, sod, etc. On account of their offensive odor they have no conspicuous vertebrate enemies, such as snakes, toads, birds or skunks, as have many other species of insects, but they are greatly infested with the larvæ of parasitic flies (*Tachina*). When the bugs become abundant, as in the summer of 1901, these parasitic flies multiply in the first brood and become so numerous in the second brood as to materially reduce the number of adults going into hibernation. In fact last fall we could not find one adult that did not have upon its body one or more eggs or parasites (Fig. 12) and under or near these empty egg shells there could be found the tiny hole where a young fly larva had bored into the interior of its host. Owing to this fact we then predicted that there would be but few squash bugs during the season of 1902, and this prediction was fulfilled to a remarkable degree.

REMEDIES.

Since these are sucking insects and do not bite the plants, they cannot be killed by poisons. The only remedies that can be effectively employed against them are clean farming, hand-picking, mechanical contrivances (Nos. 1, 2 and 4, described later), contact sprays and painting the eggs with something like pitch to destroy them.

To prevent next year's brood it is important that the vines be destroyed and the green fruits be removed just as early as possible in the fall. If this were universally done there would be no bugs of the second brood coming to maturity.

ORDER HEMIPTERA: The True Bugs, Plant Lice, Scales, Etc.

FAMILY APHIDIDÆ; The Aphids.

The Melon Louse (*Aphis gossypii*), and The Cucumber Louse (*Aphis cucumeris*).

The Melon Aphids are very small, greenish insects with globose bodies not an eighth of an inch long. Some of the adults are wingless and some are winged. As they belong to Hemiptera they agree with all insects of this large order (excepting the male scale bugs) in having only the three stages in their life history: Egg, nymph and adult. Yet the plant lice are parthenogenetic or give birth to succeeding generations of living young without mating for each generation. When winged there are two wings on each side of the body. These are long and delicate and so close together that they would be taken for a single pair. All plant lice are suctorial, feeding by sucking out the juices of the plant. They live mostly on the young leaves, terminal buds, and the unopened flowers, where their damage is greatest. (See Fig. 13.) Their effect is to check the growth and distort and crumple the leaves. The two species named above are so nearly alike in appearance and effects that no difference is to be made in this treatise. They feed on dozens of different kinds of plants, cultivated and uncultivated, and they are therefore quite difficult to exterminate.

They have probably more natural enemies than have any other kind of insects. Among these are many insectivorous insects, such as lady bugs or lady beetles, Syrphus fly larvæ (Fig. 14), minute wasp-like internal parasites, the Aphis Lion or larva of the Lace-wing, etc. (Figs. 15, 16, 17.) They are also the common food of most small insectivorous birds, and are killed in great numbers by a fungus.

They may prove serious at times if no efforts are made to prevent them, but if taken early enough in the season they are easily held in check by Mechanical Devices Nos. 2 and 3; Farm Practice Nos. 2, 3 and 4; insecticides Nos. 6, 7, 8, 9, 10, 11, 12 (a and b), and 15.

ORDER LEPIDOPTERA: Moths, Skippers and Butterflies.

FAMILY PYRAUSTIDÆ; The Pyraustids.

The Pickle Moth (*Endioptis nitidalis*) (Fig. 18.)

The larva of this moth bores into the fruits of squashes, melons, cucumbers and cushaws, feeding on the fleshy pulp, causing it to decay. It is quite a pretty brown and yellow insect called "the pickle

moth, because the caterpillar has the habit of feeding upon the cucumber, boring into and destroying it when about half grown. It is more common in the western States, and no satisfactory recommendations for its control have yet been made."—(Smith).

This insect has not yet found its way to Pennsylvania, but if it does it can probably be successfully combatted by spraying in time with the arsenites (Insecticides, 1-5) before the "worm" enters the fruits. This is to kill it when it commences to feed just as we now successfully contend with the Codling Moth by the same means and upon the same principles.

ORDER LEPIDOPTERA: The Moths, Skippers and Butterflies.

FAMILY PYRAUSTIDÆ; The Pyraustids.

The Melon-worm (*Margaronia hyalinata*). (Fig. 19.)

The melon-worm is another pest of the southern and southwestern States that is not yet common in Pennsylvania. It destroys the leaves of the water-melon and the leaves and fruit of the musk-melon. It is a light yellowish green caterpillar about an inch long.

For all such biting insects the standard remedy would be the arsenites, especially Paris green, No. 1, applied as soon as the first signs of the insect occur and continued weekly for three or four weeks.

ORDER LEPIDOPTERA: Moths, Skippers and Butterflies.

FAMILY SESIIDÆ: The Clear-wings.

The Squash-borer (*Melittia ceto*). Figs. 20 *a* and 20 *b*.)

The insect or so-called "worm" that bores in the stem of the squash, pumpkin and some other Cucurbits is the larva of a moth that is called "a Clear-wing," because it has a space in its wing that is clear and not covered with scales. The adult or moth measures over an inch in extent of wings from tip to tip, and has the front wings covered with dark green scales. There is a conspicuous tuft of red, white and black hairs on each hind leg which is characteristic and renders this moth easily determined.

It flies by day, as do all clear wings, and at night remains quiet on the leaves of the plant its larvæ infest. On this account it is

easily found and killed by using lanterns at night. It does not fly into lamp traps. In its flight it resembles a wasp.

The moth passes the winter in the ground and appears in this latitude about the last of June.

It lays its eggs singly, either on the vine or on the stalks or petioles of the leaves. The favorite place is toward the base of the vine. We have found many at the top of the leaf stem. (Figs. 21, 22.) When the larva hatches it eats into the interior of the vine or of the hollow leaf stem and follows the latter down and enters the vine. The small hole that it makes can be seen and generally fine borings or dust (excreta) can be seen at this hole. Their presence in the vine can first be detected by the presence of the dust at the small hole.

Because it is an internal feeder it cannot be killed by an insecticide. It should be cut out with a sharp knife, cutting lengthwise of the vine, and dust rubbed on the wound to facilitate healing. The vine should be covered at intervals of a few feet with damp earth over the base of the leaves that roots can be formed there. After the new roots are formed the vine will continue to grow even though it may be entirely cut off at its base. We have grown good crops on plants treated in this way. (Figs. 23 and 24.)

Another method is to plant summer varieties of squash to become large and receive the eggs and larvæ; then after the winter varieties (Hubbards and Marrowfats) are starting, gather the early fruits from the trap crops and destroy the vines by burning.

Mechanical protection from squash borers is not possible because they attack the vines after the latter are too large to be covered by netting advantageously. Pumpkin vines are commonly infested and should be burned as soon as the crop is gathered or when found dying. (Farm Practice, No. 2.)

ORDER COLEOPTERA: The Beetles.

FAMILY COCCINELLIDÆ: The Lady-bugs, Lady-birds or Lady-beetles.

The Herbivorous Lady-bugs (*Epilachna borealis*).

The adult beetles of this species are large hemispherical, yellow with black spots. The larvæ are also yellow, elongate, oval, with long branched spines. '*Epilachna borea is* is the northern and eastern species, attacking cucumber, melon and similar vines, while *E. corrupta*. is found in the southwest, injuring beans. A curious feature in *E. borealis* is the manner in which the adult works out a circle at the edge of a leaf and feeds within it until all usable ma-

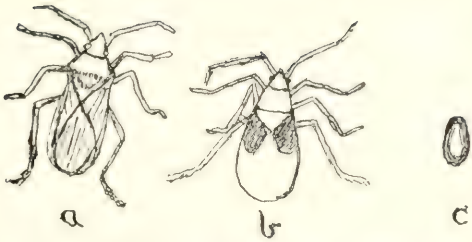


Fig. 1. Three stages of the Squash Bug (*Anasa tristis*), (*a*) adult, (*b*) nymph, (*c*) egg, x2. Drawn by E. L. Westlake, from a photograph by the author. (Reduced.)

Fig. 2. The four stages of the Striped Cucumber Beetle (*Diabrotica vittata*), magnified five diameters; *a*. Eggs; *b*. Larva; *c*. Pupa; *d*. Imago.

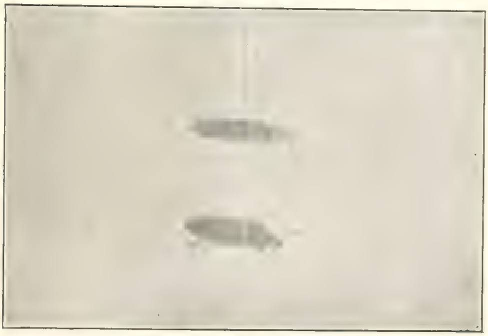


Fig. 3. Illustration of Insects with Sucking Mouth-parts. Beak partially extended. (Reduced.)

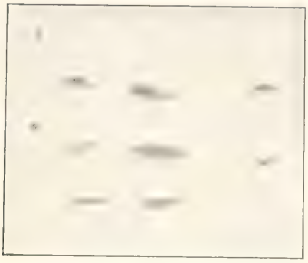


Fig. 4. Different Species of Thrips, five times natural size. The one at the upper left corner is a nymph without wing-pads.

Fig. 5. Adult Squash Bugs (*Anasa tristis*), natural size. Dorsal or upper side shown by the two below; ventral or under side shown by the two above. The two at the reader's left are males, and the two at the right are females.

Fig. 6. Squash Leaf Crumpled, showing effects of Squash Bugs. The colony of bugs living within its folds could not be entirely exterminated by spraying with kerosene. The best treatment for such a leaf is to carefully cut it off and either crush it under one's foot on the ground or drop it into a vessel containing kerosene on water.

Fig. 7. A colony of young Squash Bugs, of different ages, showing gregarious habits. In such a position as this they are readily reached by kerosene emulsion or kerosene mixture.

Fig. 8. Eggs of the Squash Bug (*Anasa tristis*), natural size, *in situ*, on the under side of a squash leaf. This shows the regular distance between the eggs, the diagonal direction of the rows, and the irregular shape of the patch as a whole.

Fig. 9. Eggs and Nymphs of Squash Bugs, one-fifth natural size. The young have recently hatched and remain in a group near the egg shells, which adhere to the leaves all summer.

Fig. 10. A group of Squash Bugs on a dead leaf in the Fall, showing where they can be killed by a stronger kerosene spray.

Fig. 11. All stages of the Squash Bug (*Anasa tristis*) At the left of the center is the female, laying eggs, below the center is a row of eggs, and below and above the female are nymphs without wing-pads; while at the upper right corner is an older nymph with wing-pads. Photographed in the field, with the insects alive and in their own natural positions. One-fourth natural size.

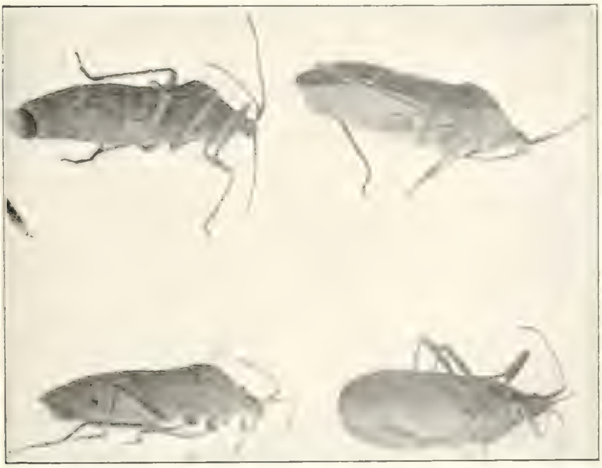


Fig. 12. Eggs of Parasites on Squash Bugs. It was through the abundance of these parasites, detroying the fall brood of 1901 after it became adult, that the bugs are rare and crops are free from serious injury during the season of 1902. Slightly more than twice natural size.

Fig. 13. Plant Lice (*Aphis*) on the unopened blossoms and young leaves.

Fig. 14. Syrphus Flies. Very important enemies of Plant Lice on all kinds of plants, (*a*) Eggs; (*b*) Larva alive and eating an Aphis; (*c*) Adult. Twice natural size. The Larva is not the same species as egg and adult here shown but is larger. It is surrounded by the remains of the Aphids it has devoured.

Fig. 15. Aphis and its Enemies This photograph shows some live Plant Lice, both old and young. Some that were killed by fungus, some exuviæ or cast skins of Aphids. Syrphus Fly eggs and larvæ (at X), and Lady Beetles. Nearly natural size.

Fig. 16. The Lace Wing Fly (*Chrysopa.*) (*a*) Egg on stalk for protection; (*b*) Larva, called Aphis Lion; (*c*) Adult Female Lace-wing. This is the individual that layed the egg shown at a. Twice natural size.

Fig. 17. Several species of Lady Beetles, taken from Cucurbitaceous plants, where they were devouring Plant Lice, Insect eggs, etc. Twice natural size. Above are the larva and pupa of a Lady Beetle.

Fig. 18. The Pickle Worm (*Endioptis nitalis*). **Reproduced from the Report of the United States Department of Agriculture. (Riley).**

terial is exhausted before proceeding to another place to repeat the operation."—(Prof. J. B. Smith.)

It is remarkable as being the only herbivorous Lady-bug. All other species are insectivorous and beneficial. In both the larval and adult stages it feeds on the leaves of nearly all the cucurbits, and pupates while attached to the leaves.

It is killed by applications of any of the arsenites, the same as are the other Coleoptera or beetles here discussed, and is likewise prevented by covering the plants. It is killed under the paper tent, Mechanical Device No. 2.

ORDER COLEOPTERA: The Beetles.

FAMILY CHRYSOMELIDÆ: The Leaf Beetles.

The 12-Spotted Cucumber Beetle (*Diabrotica 12-notata.*) Fig. 26.

The adult of this insect is a greenish yellow beetle, with six black dots on each wing-cover. It is very common on a great many kinds of plants. The adult beetle feeds on foilage, and the larva feeds on the roots of plants. It pupates in the ground and remains there during the winter. There are two broods each year, the adults of the second brood appearing during the first half of August.

The effects of this insect, the remedies to be employed, and the enemies of this insect are the same as those of the next species.

The Striped Cucumber Beetle (*Diabrotica vittata.*) Fig. 27.

This is one of the earliest and most destructive insects attacking cucurbitaceous plants. It injures all species of plants of this family as well as of some others. The beetles are about one-fourth of an inch long and are yellow, with two black stripes extending lengthwise on each wing cover.

They are too well known to need detailed description. They appear on plants by the first of June, or as soon thereafter as the young plants come above ground, and commence at once to eat ragged holes into the leaves and even to chew off the young stems. (Fig. 28.) They pair by the middle of June and continue breeding throughout the summer, there being two distinct broods which overlap and are thus indistinctly demarcated. In central Pennsylvania the second brood commences to appear about the second week of August. The adults feed on the leaves and tender vines and lay their eggs in the ground. (Fig. 29.) The larvæ feed on the roots and often cause the plants to wither and die without apparent cause. (Fig. 30.) If the

earth is carefully removed from around the wilted plant the small white "worm" may be found, and the rootlets and soft outer portion of the roots will be found eaten away. (Fig. 31.) They pupate in the ground and hibernate as adults.

The earliest remedy is mechanical protection (No. 1) by a net or cloth with finer mesh than the common coarse mosquito netting.

The adults can be killed by the arsenites (1—5), also by tobacco (11), lime (14), land plaster (13), and they can be prevented by the various methods under "Farm Practice." The larvæ can be killed by using tobacco dust or pulverized stems in the soil around the hill. We have had decided success by sticking a few holes four or five inches deep in the ground around the hill and putting about a teaspoonful of calcium carbide in each and filling again with earth. Land plaster and turpentine are also preventives. A pinch of nitrate of soda in each hill acts both as an insecticide and as a fertilizer.

Ground Beetles (*Harpalus*) and their larvæ destroy many of the larvæ and pupæ.

(See general Remedies and Preventives given later.)

ORDER COLEOPTERA: The Beetles.

FAMILY CHRYSOMELIDÆ: The Leaf Beetles. (Fig. 32.)

The White-striped Flea-beetle (*Systena blanda*). The Elongate Flea-beetle (*Systena elongata*), and The Cucumber Flea-beetle (*Crepidodera cucumeris.*)

As all the Flea-beetles belong to the same sub-family and as their habits, life histories, effects and remedies are similar we here treat them together. They can be known by their very small size and the enlarged segment (femur) of the hind leg, with the fact that they are able to jump and suddenly disappear like fleas (hence the common name), although their jump ends in a short flight. The White-striped Flea-beetle (*Systena blanda*) is one of the commonest and most destructive. (Fig. 34.)

They are the first insects of the spring to attack the plants, eating fine round holes in them before the leaves have expanded and consequently inflicting considerable injury. As the leaves grow the holes enlarge and become conspicuous with brown edges. (Fig. 33.)

The larvæ of most species mine in leaves, feeding on the fleshy substance between the two outer coverings, but they do not effect much

damage. The one generally called "The Cucumber Flea-beetle" (*Crepidodera cucumeris*), prefers potato leaves to those of cucumbers. (Fig. 35.)

Although the adults are very small they often appear in such numbers as to prove quite serious. They are too small to be kept out by netting unless very fine gauze or cheese cloth is used. On account of the readiness with which they jump with the wind they can be destroyed by thousands by Mechanical Device No. 3.

They are biters or chewers and hence can be killed by the arsenites. The remedies are the same as for the striped cucumber beetle. Bordeaux mixture is good, besides acting as a fungicide or remedy for plant disease. The tobacco decoction and arsenate of lead are also to be especially recommended.

ORDER DIPTERA: The Flies.

Whenever decay commences in any part of cucurbitaceous plants, several species of fly larvæ or "maggots" may be found. They are whitish, footless and headless grubs, without jaws or appendages. They live in the liquids that accompany decay and feed upon these and the decaying tissues. They need cause no alarm, as they are more the result than the cause of the trouble where they occur.

Sometimes one may see a wilted young plant, and upon digging into the ground find it nearly cut off an inch or two beneath the surface, and in the wilting stem, toward the top, may be found a single fly larva. This is there because the Cucumber Beetles had bitten the plant partially off and left a suitable place for the adult fly to deposit its egg.

No remedy is necessary but excessive seeding prevents disastrous results from the effects of the Cucumber Beetles and any other insects that would cut off some of the young stalks.

PREVENTIVES AND REMEDIES.

A preventive is something that keeps an insect away from the crop, and a remedy is a means of destroying it after it is present. All that we wish here to indicate is how to produce a crop of Cucurbits by successfully combatting the hosts of insects that yearly become more serious. The means to be employed may be classed in one or more of three groups, which for want of better terms we designate as (1) Mechanical Devices, (2) Farm Practice and (3) Insecticides. These overlap, and it may be difficult to tell to which some of the later suggestions may belong, but as we have tried most of them and have found them reliable we know that they can be used with safety and with feelings of security.

I. MECHANICAL DEVICES.

1. A Covering of Netting for Protection.

The netting is especially important for young plants, as it protects them from insect attacks until they are well started, when the injuries will not be so perceptible. Closely-woven mosquito netting will do for all insects but the flea-beetles and thrips, but for these pests finer material must be used. A nice way to put up the net is to cut it into squares as large as desired (about three feet each way), and stick into the ground both ends of two pliable sticks bent into semicircles and crossed at right angles at the top like the central wickets of a croquet ground. Cover them with the netting and place loose earth on the edge all the way around to hold it down. (Fig. 37.)

Another and quicker method is to incline a single stake over the plants and push or drive it into the ground. Over this place the netting and cover the margin with loose earth. (Fig. 38.)

Another method of covering plants has been highly recommended by Prof. C. M. Weed and others. It consists in covering two endboards with netting and attaching a stake to each to hold it upright when pushed into the soil. This gives a box-shaped cover with only two ends of wood, the top and two sides being netting. It has the advantage of being portable and readily packed in compact space for use another year. The mode of construction and use is shown by Fig. 39. We have not found it more effective than some of the more simple devices here mentioned, especially that of Fig. 38.

With all kinds of netting it is essential that the meshes be small enough to keep out the insects and that the edges be well covered with earth so the insects will not crawl beneath them.

A third and still quicker and therefore more economical method is to simply place the netting loosely and unsupported over the plants and fasten it down with the loose earth. It should be pulled up at the middle once about every three days in order to relieve the pressure on the plants,but if it does not rain on the earth and fasten it down the plants will exert sufficient pressure to support the netting for themselves. After a few weeks it can be removed and stored for another year. This method appears almost as effective as any, and we have tried all. (Fig. 40.)

2. The Paper Tent.

We have recently devised and tested this "tent" and consider it effective for all kinds of insects on plants small enough to be tightly covered by it. We used large sheets of brown paper thirty by thirty-six inches, procured at a newspaper office. Each is folded twice to make a block of four sheets one-fourth the original size. Then a diagonal fold is made from the corner that was the center across to the farthest corner. (See Ill. No. 41.) When this is properly unfolded and partially spread it will stand upright like a tent. About two tablespoonfulls of carbon bisulphide are poured on the ground around the plants in the hill and the paper tent is quickly placed over them and its edges covered with earth. Two persons can place one hundred tents in an hour, and by that time every living insect (except the borers) will be killed under the first that were placed and the workmen can commence to cover other plants with them. Carbon bisulphide and calcium carbide are especially effective when properly used with this device. It can be used over any and all kinds of plants that it will cover and the insects thereon will be killed, no matter what species, and the plants will not be injured. It is here described for the first time. If larger plants are to be treated two or more sheets may be pasted together. They can be stored in tight boxes away from mice and kept in use for many years. (Ill. 41.)

3. The Tarred Board. (Ill. No. 42.)

This device is a modification of the tarred cloth and for some reasons is preferable. Thin boards are nailed on a cross pole in such a way as to give a flat surface about thirty inches wide by forty inches long. Over the broad board thus made tar or pitch is to be smeared. When a person carries this tar board by the pole or handle with the tarred side toward plants and another person from the windward side of the row brushes insects toward it they strike it and are killed by thousands. It can be operated successfully by one person. (Fig. 43.)

This is especially recommended for thrips, flea-beetles, striped cucumber beetles and plant lice. It can be used to advantage for

such insects as these on any kind of plants, but those insects, like plant lice, that do not jump readily must be brushed against it. This is such a cheap and effective device that it should come into general use.

4. Board Traps. (Fig. 44.)

Simply flat boards are placed on the ground around plants, and as it is warmer under them at night than in the air above them, insects of certain species congregate there and in the morning may be brushed off into a can or tray of kerosene and water and thus killed at once.

This is especially recommended for squash bugs, cut worms, false army worms, crickets, slugs, etc.

II. FARM PRACTICE.

1. Clearing up all Rubbish.

It is particularly important that this be done late in the fall and in the winter. If debris of all kinds available then be raked together and burned many hibernating insects will thus be killed. However, it is advisable that a watch be kept for toads which hibernate under leaves, etc. These animals are of great value as destroyers of insects and slugs and they should be preserved with care. They are too frequently burned with leaves and rubbish in the winter time.

Rail fences are favorite places for insects like the squash bug to pass the winter in hibernation, as well as favorable to the growth of weeds. Wire and board fences can be kept cleaner and consequently will contribute toward keeping down insect pests.

2. Clearing Away Unused Portions of Crops.

Just as soon as the desired portion of a crop is gathered the remaining parts of the plants, green fruits, stems, leaves, roots and all, should be burned, buried or thrown in a heap to decay. The late fall brood of nearly all species of insects mentioned in this Bulletin would be reduced if this practice were general. This means that but few individuals would be able to live through winter and infest the crops for a new brood in spring.

If at any time plants or parts of plants are killed by insects they should be burned at once. This is a general principle of great importance and applies to all crops.

3. Killing all Weeds.

Since some of the insects (particularly the plant lice and flea-beetles) mentioned above feed on several kinds of weeds it is very important that the premises be kept free from weeds, because otherwise the pests are able to multiply on the uncultivated plants and from them, constantly come to infest the cultivated crops.

4. Rotation of Crops.

This practice should be followed for the sake of the strength of the plants if not for the repression of insects. Many pests stay in one locality, and if the same kind of crop is grown consecutively for many years in the same soil the insects accumulate there and become most serious.

To rotate with plants that are similar and attacked by the same insects will not avail much. The plants should be of widely different character and any insects that remain are thus starved.

5. Planting Trap Crops.

This is done in two ways. One is to make a very early planting of the kinds of plants to be set out later, intending to have the insects infest this trap crop with their eggs and then destroy them. Often it is desirable to start the trap plants indoors in order to have them large enough for the insects to attack at once. Sometimes it is desirable to spray the trap crop with kerosene or some other insecticide that will be sure to kill the pests even though the plants are also injured. Often it is possible to gather an early crop from the trap plants before destroying them. For example, it is recommended to plant traps of early summer squash to protect the winter varieties to be planted later.

The other method is to plant some kinds of plants that the insects prefer to the ones we wish to raise. For example, this year we have completely protected our squash from attacks of flea-beetles by planting a few potatoes around among the vines. These insects prefer the potato and other Solanaceous plants to the Cucurbitaceous, and consequently when it was possible went to the former in place of the latter. In fact, that is why we had to photograph a potato and bean leaf instead of one from a Cucurbit to show the work of the flea-beetle. They were serious pests on our squash last year, but this year none occurred on squash, cucumber or melons, all having potato vine traps. This test has never before been made or published.

6. Hand Picking.

This consists in going over the plants every morning during the weeks of the greatest abundance of the insects especially during the mating season, and picking off or brushing the insects into oil and water. This is especially to be recommended for squash bugs. The board traps greatly facilitate this means of gathering the pests. It is the best means of combatting the tomato worm, celery caterpillar and many other conspicuous insects. Clusters of eggs should likewise be picked off.

7. Excessive Seeding.

This consists in the well-known method of planting in one hill more seeds than are to be grown, with the expectation that the insects will destroy some. This is a good plan when it is necessary

but it should not be required as it is better to exterminate the insects. For several insects that are difficult to combat, this practice is often resorted to.

8. Using Fertilizers.

It is very desirable that all plants have a strong, vigorous growth, for they are thus able to withstand the attacks of insects better than can weaklings. Any kind of fertilizer is valuable in overcoming insect attacks because it promotes vigor, but one of the best is a pinch of nitrate of soda in each hill or at the root of each plant. This produces the needed rapid growth and also acts as an insecticide. Tobacco dust is also a valuable fertilizer and insecticide. Its commercial value as a fertilizer is $25.00 per ton.

9. Starting Plants Early.

The purpose of this practice is to have them as large as possible before the insects appear. An attack that will kill a small plant will but slightly injure a large one. There is an advantage in starting plants indoors in order to have them large enough to withstand insect attacks when set out, besides the early yield of produce.

10. Late Fall Ploughing.

This practice is valuable to destroy those insects, such as the Squash-borer, the Striped Cucumber Beetle and perhaps the Spotted Cucumber Beetle, that pass the winter in the ground. If they are turned over and exposed during the winter a great many insects are killed by ploughing in the fall. Those that pass the winter as pupæ are especially likely to be killed by the breaking up of their pupal cases or cells.

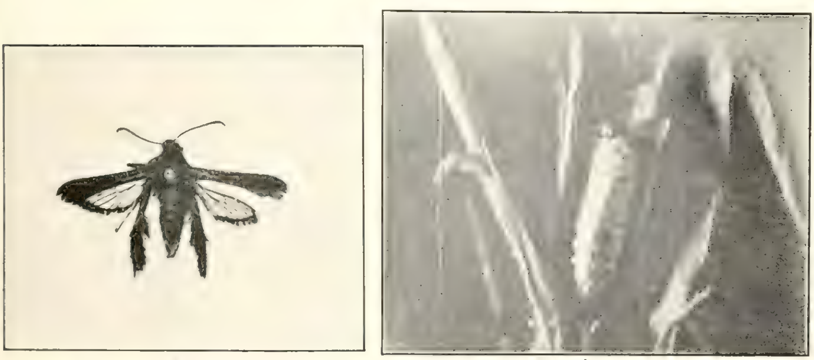
11. The *early* Application of all Preventive and Remedial Measures.

The importance of this can not be too greatly emphasized for all species of insects, and there are many that can not be successfully combatted unless practical measures are taken as soon as they make their appearance. Among these are such as the Plant Lice or Aphids. In June while the vines are small and the Aphids first migrate to melons, etc., from their food plants of winter and spring, they can readily be killed by fumigating the vines or spraying as directed elsewhere in this article; but if this is neglected until the vines are large and fruit is set it is almost impossible to rid the field of the pests.

III. INSECTICIDES.

As stated in the early part of this article, insecticides are of two general kinds, according to the structure of the mouth and the feeding habits of the insect to which they are to be applied. Those species that chew their food can be killed with internal poisons (A), if they live where they can be reached; and those that are suctorial must be killed by contact applications (B).

Fig. 19. The Melon Worm (*Margaronia hyalinata*). Reproduced from Saunder's "Insects Injurious to Fruit."



a *b*

Fig. 20. The Squash Borer (*Melittia ceto*). *a*. Adult Female Moth, **natural size**. Photographed from nature, with a vertical camera. *b*. **Full grown** larva, in squash vine, just as it was split open by the writer.

Fig. 21. Leaf of Pumpkin, showing where a larva entered it at x and worked downward and into the vine through the inside of the base of the leaf-stalk. Larva in the vine, at the left, just below the lower shriveled petiols or leaf stalk at the left. One-fourth natural size.

Fig. 22. External evidence of the Squash Borer beginning its work. Note the finely-ground material (*excreta*) on the outside of the vine.

a

b

Fig. 23. Larva in vine which it has nearly cut off. One-eighth **natural size.** (Where lines from *a* and *b* would cross.)

Fig. 24. Terminal portion of the vine shown in 22, growing after it had been cut off near the original root It continues to grow because it was covered with earth near the portion shown at the right and just below the center. It was well-rooted there.

Fig. 25. The Herbivorous Lady Bug (*Epilachna borealis*). From Comstock's "Manual of Entomology."

Fig. 26. Spotted Cucumber Beetles (*Diabrotica 12-notata*), adult Males and Females. Twice natural size. The two at the left are males; at the right are females. Those above show the dorsal or upper side; those below, the ventral or lower side. There are artificial bands, due to reflection of light.

Fig. 27. The Striped Cucumber Beetle (*Diabrotica vittata*), natural size. The two above show the dorsal or upper side, and the two below show the ventral or lower side. The two at the left are males, and the two at the right are females.

Fig. 28. Effects of the Striped Cucumber Beetles on young plants. At the center and toward the upper right corner of the picture are shown small plants that are wilting because they are partially cut off just beneath the ground by these Beetles when the latter entered it to deposit their eggs.

Fig. 29. Larvæ of Striped Cucumber Beetles, nearly natural size. These were taken from the ground at the same time and indicate differences in age in accordance with the differences in size.

Fig. 30. Effects of the Larvæ of the Striped Cucumber Beetle on older Cucumber Plants. The vine in the fore-ground is wilting without apparent external cause.

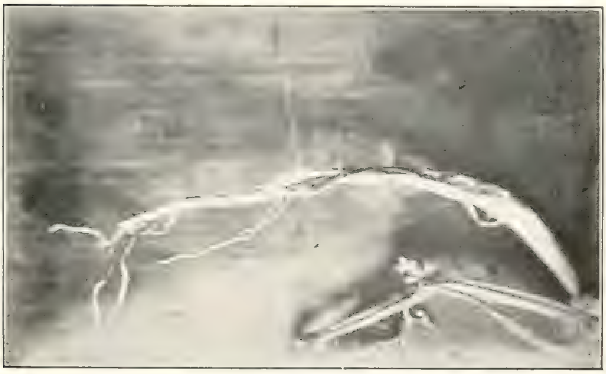


Fig. 31. Roots of the Vine shown in Fig. 30, showing that all of the softer outer substance and most of the rootlets have been eaten away by Larvæ of the Cucumber Beetles.

Fig. 32. Several Species of Flea Beetles, ten times natural size. Taken with a micro-photographic camera. In the lefthand column the dorsal side or back is shown, and in the right column the ventral or under side is shown. Note the enlarged thighs of the hind legs, adapted to jumping. The top picture is a pair of Striped Flea Beetles (*Systenablanda*), while the second and smallest pair is the Cucumber Flee Beetle (*Crepidodera cucumeris*).

Fig. 33. The Characteristic Effects of the Flea Beetles on Young Beans; one-half natural size.

No. 34. The White-striped Flea-beetle (*Systena blanda*). Natural size. The dorsal or upper side is shown by the upper pair, and the ventral or lower side is shown by the lower pair. At the left are males; at the right, females.

Fig. 35. The Cucumber Flea Beetle (*Crepidodera cucumeris*) and its Effects on Potatoes. Note that all the Flea Beetles prefer leaves of Potatoes and Beans to those of the Cucurbitaceous Plants.

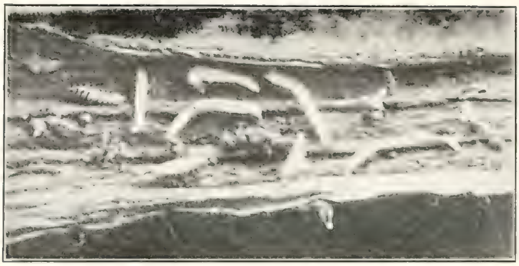


Fig. 36. Fly Larvæ and Pupæ, of different species, but such as may be found in any part of a Cucurbitaceous Plant as soon as it commences to decay. They probably hasten the decay, but are not the original cause. At the right are eggs, in the center are larvæ, and at the left are pupæ.

Fig. 37. Frame on the right, and net over frame on the left, showing how pliable twigs may be used to form an inverted basket to hold netting which protects plants from insects.

Fig. 38. Inclined Sticks at right, and a similar device covered with netting at left. The simplest, cheapest, quickest, and most satisfactory means of supporting netting over plants.

Fig. 39. Netting attached to End-Boards, covering Plants as an inverted box. Also, one End-Board not covered, showing method of attaching sharpened stake to hold it upright when stake is pushed down.

Fig. 40. Netting Material Lying in loose Folds over Plants, without support. Note that with all kinds of Nets the edges must be carefully covered with fine soil. Common Mosquito netting is too coarse to keep out Thrips, Plant Lice, and the various small Beetles.

Fig. 43. Tarred Board, operated by one person. This is effective if properly and carefully done. After using this ten minutes, there were over two hundred insects on one square foot of the board.

Fig. 41. Paper Tents for Fumigating Plants. The Methods of Folding is shown by the one held in the hand of the assistant.

Fig. 42. Tarred Board, used by two Men, for Thrips, Flea Beetles and Plant Lice. A cloth soaked with kerosene, pitch or tar and supported by a frame will also be affective.

Fig. 44. Board Trap, showing effectiveness for Squash Bugs.

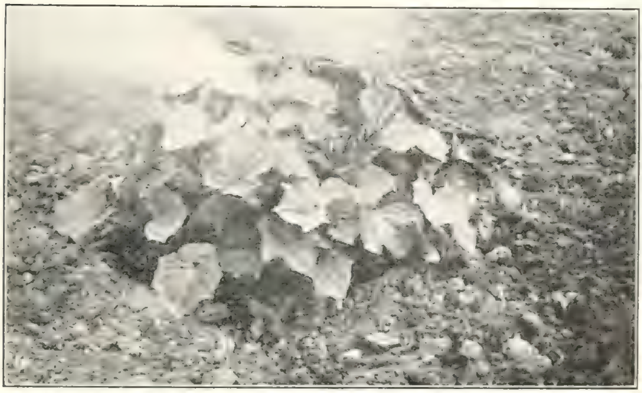


Fig. 45. Cucumbers and Beans, growing simultaneously not fifteen feet apart. Note that the Beans are seriously injured by Flea Beetles and the Cucumbers are not attacked. This indicates the value of a few beans, potatoes, and early squash or pumpkins as trap plants to take insects away from the more desirable crop to be planted later. Compare with Fig. 33 for the Beans.

Fig. 46. Young Cucumber Plants Eaten by Earthworms. At the farther end of the straw from x were two holes of earthworms with portions of small Cucumber plants and other vegetation cut off and sticking in them.

Fig. 47. The Young Fruit of Squash, eaten by Millipedes, Centipedes and Slugs, all of which were alive upon this at the time it was photographed, but as most of them were moving they are not plainly shown.

It should be remembered that most substances that kill insects will also kill plants if applied in sufficient strength. Fortunately there is a safety limit of strength at which insects are killed and plants are uninjured. Our object should be to apply insecticides of such strength as to have the desired effect on the pests, but to save the plants. An insecticide should be applied at the proper time and for a certain kind of insect, and should be selected in accordance with the recommendations made for the destruction of the specific kind of insect under contemplation.

A. Internal Poisons or Stomach Poisons, for Chewing Insects.

1. Paris Green. The poisons that contain arsenic are called Arsenites and Arsenates. Paris green is the arsenite of copper and contains about 69 per cent. of arsenic. It can be applied as either (a) a powder, or (b) in liquid.

(a) Paris Green as a Powder: This is to be dusted on the plants, but it should be mixed with some diluting powder in proportion of one part of Paris green to from 20 to 50 parts of the dilutant. On a small scale, flour is generally used, but air slaked lime, land plaster and even road dust or wood ashes are good. It will adhere to the leaves better if applied early in the morning while the dew remains or just after a shower of rain, while they are yet damp. It is washed off by a dashing rain and should be repeated after each rainfall. If there is no rain it is well to repeat the dusting about once every two weeks.

For applying dusts or powders a "powder gun" or bellows will prove useful but not essential. Small hand "puffers" for this purpose are common in stores. A good method is to put the powder into a thin cloth sack or coffee bag, carry it over the plants to be dusted, and pound it with sticks. Especial care should be taken to dust it over the vines of plants for the young borers when they first hatch and commence to eat their way toward the inside of the plant. This is the only opportunity to kill them without cutting them out or piercing them with a sharpened wire.

(b) Paris Green in a Liquid: The Cucurbitaceous plants are very tender and easily injured. Therefore Paris green can not be applied to them in as strong a mixture as to apple trees, but it must be diluted, as for peaches and plums. The formula for vines is:

One pound Paris green to 200 gallons of water, or 4 ounces to 50 gallons. Stir the poison well into the water, then mix with a little water an amount of air slacked lime equivalent to that of the Paris green used, and stir the "milk of lime" into the poisoned water. This is to prevent burning the tender foilage. It MUST be applied as a spray and not merely sprinkled on the plants. The work can pro-

perly be done by any spraying apparatus that will throw a genuine spray or mist. A knap-sack sprayer should be on every farm.

2. London Purple. This is mostly composed of an arsenite of lime, and contains about forty-two per cent. of arsenic. It is therefore not as strong as Paris green and is cheaper. A little more of it must be used in making up mixtures, and the lime should never be omitted. It is to be applied either as a powder or liquid, just as is Paris green.

In applying nearly all insecticides used with water it should be remembered that they are not dissolved but are merely held in mechanical suspension, and it is therefore a mixture instead of a solution. The liquid should be well stirred frequently to prevent the poison settling at the bottom. If it is not stirred often it will settle at the bottom of the vessel and the last to be used will be much stronger than the first.

3. Arsenate of Lead. Do not put this into metal vessels or they will be corroded. Wood or glass can safely be used. Formula:

4 ounces of 50 per cent. arsenate of soda.
11 ounces of acetate of lead.
150 gallons of water.

Dissolve the acetate of lead and arsenate of soda separately, each in four quarts of water, in wood, glass or earthenware, then stir them into the remainder of the water in the larger vessel. Apply as a spray as with other poisons. All such substances should be labelled and kept out of the reach of children, poultry or live stock, as they are deadly poisons. If they were not poisonous they would be of no avail for the purposes to which we propose to put them.

It is safe to spray all plants, even cabbage, with such applications, but they should be well washed with dashing water before being eaten or should not be gathered within two weeks from the time of the last application.

4. Arsenite of Lime. This can be made according to the following formula:

1 pound white arsenic.
2 pounds quick lime.
1 gallon water.

Boil this mixture forty-five minutes. (It will not injure metal.) Keep it in a closed vessel, as a jug, properly labelled "Poison," and whenever it is needed use it in proportion of one quart to fifty gallons of water. It can be kept as long as desired, and will be found quite effective for all kinds of biting insects. We have not yet had opportunity to try this substance, but it is so highly recommended by those who have tried it that we do not hesitate to endorse it as a first class insecticide.

5. The Bordeaux Mixture and Paris Green: This has the advantage of being both a fungicide for plant diseases and an insecticide

for their insect pests. It is in common use. The Bordeaux mixture itself without the Paris green is a fungicide rather than an insecticide. The former is made as follows:

4 pounds copper sulphate (blue vitriol).
4 pounds unslaked lime.
25 gallons of water ("full strength solution"), or
50 gallons water ("half strength solution").

Do not use metal. Dissolve the copper sulphate in water. Solution can be hastened by heating. Slake the lime separately in enough water to make a "cream." Pour the copper solution into the larger vessel of water, and strain the "milk of lime" into it through a fine sieve or cloth, stirring the liquid into which it is strained.

Whenever lime is to be used in any substance to be applied as a spray it should first be strained carefully to prevent it clogging the nozzle.

To complete the mixture as an insecticide use four ounces of Paris green to every fifty gallons of the Bordeaux mixture as made according to the formula here given.

This mixture is particularly recommended for Thrips, Flea-beetles, etc.

B. Contact Applications, for Suctorial Insects.

6. Kerosene Mixture with Water. It has recently been determined that it is not necessary, in combatting most insects, to take the trouble of making a kerosene emulsion (7), as a mere mechanical mixture of oil and water is sufficient if the kerosene is thrown in a very fine spray. The mixing is done by the apparatus as it throws the spray, the kerosene being carried in a vessel separate from the water. Several devices for this purpose are now on the market, but one of the best is the Kerowater Knapsack Sprayer. It can be purchased of most dealers. It can be set to make the mixture of any desired percentage. For Cucurbits it should not be used above eight per cent., and five per cent. will generally be found strong enough. Wherever the insects are not on plants that are to be kept growing it can be increased to twenty per cent. and will then prove certain and speedy death. It is particularly recommended for Squash-bugs. Even though plants are to be burned after frost, they should first be well sprayed with a strong mixture to kill the bugs that then collect on them and would remain over winter to infest the next spring's crop.

7. Kerosene Emulsion. This is a famous remedy for all kinds of suctorial insects. Formula:

$\frac{1}{2}$ pound hard common coarse laundry soap.
1 gallon water.
2 gallons kerosene.

Shave the soap fine and dissolve it in the boiling water. Pour it into the kerosene (away from fire) while hot, and churn it through a force pump or sprayer until it becomes a thick creamy mass. It will keep as long as desired. For use, thoroughly mix one part of this with nine of water. Apply as a spray, thoroughly, to all parts of the plants and on both sides of the leaves. It must come into contact with the bodies of the insects in order to kill them. It is especially recommended for plant lice and Squash-bugs, but will kill all kinds of insects with which it comes into contact. It has the advantage of the kerosene mixture in the fact that it is not as liable to injure foliage.

8. Whale-oil Soap. This is made by dissolving two pounds of the potash whale-oil soap in one gallon of hot water. It is applied either as a spray or as a wash. As the latter, it can be applied with a brush, but it is a winter wash, mostly for scale insects, and under no circumstances should it be applied to delicate leaves. When Squash-bugs are not on the living plants they can be killed with this.

9. Carbon Bisulphide. This is explosive with fire. It kills by its poisonous fumes, which are heavy. It is especially used to destroy insects in stored grain, but can be employed as a fumigant. One teaspoonful in any kind of a vessel or a clam shell under each of the tents described as Mechanical Device No. 2, will kill every kind of insect present in less than an hour and will not injure the plant. It should be sold by retail druggists at twenty-five cents per pound, or less.

10. Gasolene and Benzine. The fumes of these substances kill insects, but they should be left long enough to insure death, or should be buried or burned when stupefied. Gasolene is the cheapest substance that can be quickly used under tents described as Device No. 2. When it is poured on the ground a greater quantity is needed than when placed in vessels.

11. Calcium Carbide. This is the substance that is used with water to generate the acetylene gas that is now used for illuminating purposes. We do not know of its previously having been used in this country as an insecticide, but our experiments demonstrate its value for this purpose. For insects infesting the soil, a smooth and sharpened stick should be pushed into the ground to as great a depth as they are found (generally from four to six inches), and a teaspoonful of the carbide should be dropped into the hole and the latter then firmly filled with damp earth packed into it. The carbide readily absorbs moisture from the earth and generates gas which permeates the earth and kills all kinds of insects found therein, as does carbon bisulphide. We have killed most of the larvæ and pupæ of beetles around cucumber roots by four or five holes around each hill.

For all kinds of insects on plants above ground, use the paper tents described as "Mechanical Device No. 2," and put under each about a teaspoonful of carbide, either on damp soil or in water, and leave it for an hour. Vegetation is not injured.

12. Tobacco. This is a good insecticide for certain species when used either as a fine dust or in a decoction. It will not injure the plants, and will act as a valuable fertilizer. It should come into contact with insects above ground, as they will not eat it.

For insects feeding beneath the surface of the soil nothing is better than tobacco stems or dust placed around the plant and stirred into the soil. They do not eat it, but can not avoid coming into contact with it. The stems can be procured at little or no cost from cigar factories. Stems are as useful as any part of the tobacco plant in making a tea or decoction. This should be applied as a spray.

13. Sulphur. This is often applied as a powder, but is too expensive for general application on a large scale. It is not necessary to use the pure "flower of sulphur, or powder form, but it may be mixed with several times its bulk of some kind of dust, as directed for Paris green, although the proportion of the dilutant must be only about one-third as great.

14. Land Plaster. This is recommended more as a repellant than as a remedy. It is also a fertilizer. It is applied by sprinkling it on the plants or sowing it broadcast over the field. When it is sown with the wind it drives certain species of insects to plants and weeds to the leeward. It is more effective as a repellant if some turpentine or kerosene be mixed with it.

15. Air-slaked Lime. This is used as in Land Plaster (No. 14), and is even more effective. The Cucumber Beetle, especially, is driven before it, and can be kept away from the plants by its frequent use. Of course, a repellant only drives insects away, and does not kill them. This means that they become more abundant upon the plants to which they are thus driven, but it sometimes a good plan to drive them to one side of the field and there spray with some killing insecticide, according to that recommended for the species in question.

OTHER INVERTEBRATE ANIMALS INJURING CUCURBITACEOUS PLANTS.

Besides the insects discussed in the preceding text, we have found two species of slugs (Limax), two of Centipedes and one of Millipeds, injuring the fruits of cucurbitaceous plants by eating into them.

They are especially bad when the weather is very damp and the fruits lie in shaded spots. (See Fig. 47). The young squash shown in Fig. 47 was attacked by all of these pests, which were present upon it at the time it was photographed, but as they were crawling they are not plainly shown.

The remedy is either a spray of Paris green upon the fruits, or better, a layer of wood ashes or other light dusty material on the ground around the hill and under the fruits. The latter can be regarded as a specific against these pests.

We have found some of our young plants cut off and pulled into holes by earthworms. It is a sure indication of their work to find the vegetation drawn into small, round and smooth holes. (Fig. 46.) They can be killed by salt water poured into the holes.

MODERN DAIRY SCIENCE AND PRACTICE.

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INTRODUCTION.

Dairying has for its objects the production of milk and the manufacture of various food products from milk. Dairying may, therefore, be divided into two fairly distinct departments: Dairying (1) as a branch of agriculture, and (2) as a manufacturing industry.

Considered as the source of milk production, dairying is a branch of agriculture; for the producer of milk tills the soil, raises food crops for the cattle, rears dairy animals, and obtains milk as his finished product. He is a manufacturer, employing agricultural methods. Considered as a source of cream, butter, cheese, etc., dairying is a manufacturing industry. The maker of butter and cheese starts with milk as his raw material and employs methods that are essentially industrial and in no way connected with agriculture proper. While these two departments of dairying have in the past been carried on largely side by side on the farm, the modern tendency has been toward a more complete separation. Attention is here called to these two divisions of dairying, because it is the writer's purpose in this treatise to dwell almost entirely upon the second division. To attempt to cover the field of dairying in its broadest sense would practically involve consideration of a large portion of the broad domain of agriculture.

Dairying is both an art and a science, whether considered in its restricted or broad sense.

The art or practice of dairying embraces certain practices and processes which have been gradually developed by experience and observation. The art of dairying, in its widest application, teaches how to cultivate the soil for the production of certain crops; how to make and use fertilizers; how to breed, feed and care for dairy animals for the production of milk; how to produce cream, butter, cheese, etc., from milk.

The science of dairying embraces a collection of the general principles or leading truths, arranged in systematic order, relating to the operations of dairying. Thus, among other things, the science of dairying explains the growth of animals, the relation of foods to milk production, the chemical composition and physical properties of milk and its products. It consists of an application of the truths of such sciences as physiology, chemistry, physics, botany, etc., to the practical operations of dairying.

Dairying has undergone many profound changes during the last generation, and more particularly during the last fifteen years. This is true of both the agricultural and the manufacturing phases of dairying. We can fully realize this by noticing the changes in its very language. Even ten years ago few dairymen would have been able to use intelligently, if at all, many of the expressions that are very common now, such as bacteria, lactic acid fermentation, pasteurization, sterilization, separator cream, ripened cream, fat basis for paying dividends, ripening tests, etc., etc. With all the advance in knowledge and the improvement in practice that we have witnessed in recent times, there are still many unsolved problems in dairying; but we do well to be impressed with the great things which have already been accomplished and to appreciate the advantageous position we are now in for making further progress, compared with the position we were in only fifteen years ago.

These changes for the better have been brought about through the combination of a variety of educational agencies, among which may be mentioned our agricultural experiment stations, dairy schools, State Departments of Agriculture, farmers' institutes, the agricultural press, farmers' clubs, etc.

Our dairy products, as a result of improved methods of producing milk and of improvement in manufacturing processes, are greatly superior on the average to those we made half a generation ago. The consuming public has, to some extent, become more choice in its tastes and exacting in its demands; in other words, the present standards required for dairy products are higher than they were.

The object of this little treatise is to present, with a moderate degree of fullness, some of the results of these recent years of progress, so as to give the reader some idea of what constitutes "Modern Dairy Science and Practice."

CHAPTER I.

THE CHEMISTRY OF MILK.

1. General Composition of Milk.

In milk, as well as in most of its commercial products, we find the following compounds and classes of compounds:

(1) Water.
(2) Fat.
(3) Nitrogen compounds or proteids.
(4) Sugar.
(5) Salts or ash.
(6) Gases.

In giving the description of any individual chemical compound in connection with the chemistry of milk, we shall not need to repeat the description when we come to consider that compound in connection with the products of milk; for, it will be found, the description given here will apply to the same compound wherever we find it. The word milk, as we shall use it, refers always to cows' milk, unless otherwise stated.

2. Water.

1. Chemistry.—The water present in milk and its products, however much its presence may be disguised, is one and the same compound of hydrogen and oxygen, with which we are everywhere familiar. The water in milk and its products is simply plain, common water, possessing no chemical peculiarities to distinguish it from water found anywhere else. It is only ordinary water in the company of other chemical individuals.

(2.) Purpose.—The water in milk serves the purpose of holding in solution the soluble constituents of the milk. It also acts as a diluent, better fitting the mixture as animal nutriment.

(3.) Amount of Water in Milk.—The amount of water contained in milk varies considerably, depending upon a variety of conditions, such as individuality, breed, stage of lactation, age, character of food, amount of water drunk, condition of health, etc.

(a.) Single Milkings.—Taking single milkings of individual cows, we may find the amount of water in 100 pounds of milk varying from 82 to 90 pounds or more, corresponding to 10 to 18 pounds of total solids.

(b.) Lactation Period of Single Cows.—In case of milk from single cows for an entire period of lactation, the variation of water may range from 84 to 89 pounds, corresponding to 11 to 16 pounds of total solids.

(c.) Herds.—Taking milk from herds of cows, the variations of water are within narrower limits, usually ranging from 86 to 88 pounds in 100 pounds of milk, corresponding to 12 to 14 pounds of total solids.

In the case of average milk, as found in the United States, 100 pounds of milk contain from 87 to 87 1-4 pounds of water, corresponding to 12 3-4 to 13 pounds of solids.

(d.) Breed.—As regards the influence of breed of cow upon the proportion of water in milk, the following figures, taken from the Geneva (N. Y.) Station records, serve as a fair illustration:

Name of Breed.	Lbs. of water in 100 lbs. of milk.	Lbs. of total solids in 100 lbs. of milk.
Holstein,	88.20	11.80
American-Holderness,	87.35	12.65
Ayrshire,	87.25	12.75
Shorthorn,	85.70	14.30
Devon,	85.50	14.50
Guernsey,	85.10	14.90
Jersey,	84.60	15.40

(e.) Advance of Lactation Period.—The following figures, showing the variation of water in milk with advance of lactation of period, are based upon averages derived from an aggregate of nearly fifty lactation periods of individual cows, covering the first ten months of lactation:

Month of Lactation.	Lbs. of water in 100 lbs. of milk.	Lbs. of total solids in 100 lbs. of milk.
1,	86.00	14.00
2,	86.50	13.50
3,	86.53	13.47
4,	86.36	13.64
5,	86.25	13.75
6,	86.00	14.00
7,	85.82	14.18
8,	85.67	14.33
9,	85.54	14.46
10,	85.17	14.83

We notice a general tendency for the water to increase for three months, after whcih there is a constant decrease to the end of the lactation period. A similar tendency is shown in the illustration given below, which covers a large number of samples of milk obtained from cheese factories, representing practically the first six months of the lactation period.

Month.	Lbs. of water in 100 lbs. of milk.	Lbs. of total solids in 100 lbs. of milk.
May,	87.44	12.56
June,	87.31	12.69
July,	87.52	12.48
August,	87.37	12.63
September,	87.00	13.00
October,	86.55	13.45

(f.) Age. There are not available many data giving reliable information in respect to the influence of the age of a cow upon the amount of water in milk. There is more or less variation in different individuals. From the limited amount of data accessible, there appears to be a general tendency for cows to produce milk with least water during the second period of lactation, after which the amount of water in the milk increases with the age of the animal.

3. Milk-Fat (or Butter-Fat).

1. Milk-Fat a Mixture.—Milk-fat is not a single, invariable compound, but is a somewhat variable mixture of several different compounds, each of which contains the elements carbon, hydrogen and oxygen, combined in different proportions. Each of these separate compounds, contained in milk-fat, is formd by the chemical union of glycerin with some acid of a particular kind. These glycerin-acid compounds contain about ten different acids, but some of them are present in very small quantities; in fact, 90 per cent. of milk-fat is made up of only four of these compounds. We can, in a general way, represent the composition of these four most important glycerin-acid compounds of milk-fat in the following manner:

Glycerin and palmitic acid form palmitin.

Glycerin and oleic acid form olein.

Glycerin and myristic acid form myristin.

Glycerin and butyric acid form butyrin.

These four compounds are present in milk-fat (or butter-fat) in something like the following amounts:

Palmitin, 40.5 per cent.

Olein, 34.0 per cent.

Myristin, 10.5 per cent.

Butyrin, 6.2 per cent.

The proportions of these constituents of milk-fat vary somewhat and this variation influences the character of the milk-fat.

(2.) Melting Points of Constituents of Milk-Fat.—In order to understand more fully some of the properties of milk-fat, we will briefly notice some of the more important properties of the above-mentioned compounds.

Palmitin has a rather high melting point, 144 degrees F.

Myristin melts at 129 degrees F.

Olein and butyrin are liquid at ordinary temperatures. Olein has the important property of being able to dissolve and hold in solution the less easily melting palmitin and myristin, above certain temperatures.

Palmitin and myristin tend to produce hardness in butter; olein and butyrin, softness.

(3.) Glycerin is present, chemically combined with acids, in all fats. It forms, on an average, about 12.5 per cent. of pure milk-fat or butter-fat.

(4.) Physical Properties of Milk-Fat.—Milk-fat, in pure, fresh condition, appears at ordinary temperatures as a soft, white to yellowish mass, with mild taste and very slight odor. It easily takes on a granular structure. It melts easily and is lighter than water.

Our knowledge of the color of milk-fat is very limited. Whether the color is a property of some one of the compounds of milk-fat, or whether it belongs to some special substance, mechanically held by the milk-fat, we can not say positively, but the latter supposition is probably nearer the truth. It is well established that the color of milk-fat varies with individual cases, with breeds, with advance of lactation and with the food.

(5.) Milk-Fat in Form of Globules.—Milk-fat is present in milk in the form of very small, transparent globules, too small to be seen by the unaided eye. The sizes most commonly met with are between 1-2500 and 1-15000 of an inch in diameter, and the average diameter is not far from 1-10000 of an inch. Some globules are as large as 1-1500 of an inch and some as small as 1-40000 of an inch. The smaller fat-globules are more numerous than the larger ones. In one drop of average milk there are about 150,000,000 fat globules.

Formerly it was very generally believed, and is still held by some, that fat-globules of milk are surrounded by a membranous covering. In some respects, fat globules behave as if they were enclosed in a membrane. The theory also has been advanced that the fat-globules are surrounded by a semi-solid membrane of slime. Without going into details to state the reasons, we may accept it as established beyond reasonable doubt that fat-globules have no special covering, but are simply minute particles of fat floating free in

milk in the form of an emulsion. There is no difference in the composition of the fat in the large and small globules.

(6.) Amount of Fat in Milk.—The amount of fat present in normal milk varies greatly, going, in the case of single milkings of individual cows, below 2 per cent. and above 10 per cent. The average of fat in the milk of herds of cows varies commonly between the limits of 3 and 5 per cent. The average amount of milk-fat in milk produced in the United States, taking the true average for an entire year, lies between 3.75 and 4 per cent., and somewhat nearer the latter figure.

Many of the conditions that affect the amount of fat in milk have been studied and are well established, while others are but little understood. We will consider briefly some of the better-known conditions.

(a.) Individuality.—It is uncommon to find in a herd of cows any two individuals whose milk contains the same per cent. of fat, whether we consider individual milkings or the average of many milkings. This is simply one of many factors that go to make a cow's individuality.

(b.) Breed.—It is well known that the per cent. of fat in milk varies in a more or less characteristic way with the kind of breed. While there is marked variation in indivduals of the same breed, there is found to be a fairly uniform difference, more or less marked, if we take the average of several individuals. It is largely owing to this influence that we find the milk of one country differing from that of another, or the milk of one section of a country differing from that of another section. For example, the average per cent. of fat in milk in Germany and Holland is fully one-half per cent. lower than in this country, because the prevailing breeds of cows there are the ones producing milk comparatively low in fat. The figures given in the following table are taken from the records of the Geneva (N. Y.) Station and represent averages of several individuals covering several periods of lactation:

Name of Breed.	Per Cent. of Fat in Milk.		
	Average.	Lowest.	Highest.
Holstein,	3.36	2.88	3.85
Ayrshire,	3.60	3.20	4.24
American-Holderness,	3.73	3.49	3.92
Short-Horn,	4.44	4.28	4.56
Devon,	4.60	4.30	5.23
Guernsey,	5.30	4.51	6.13
Jersey,	5.60	4.96	6.09

(c.) Age.—So far as published data throw light upon the question of the influence of age upon the amount of fat in milk, the more common tendency appears to be for milk to become less rich in fat with each succeeding period of lactation, especially after the second, though individual exceptions to this tendency are not infrequent. We need more extended data bearing upon this point before we can speak with any degree of positiveness.

(d.) Advance of Lactation Period.—In general, it is found that the per cent. of fat in milk increases as the stage of lactation advances. The following figures represent the averages obtained from an aggregate of nearly fifty lactation periods of different cows, covering a period of ten months:

Number of Month of Lactation.	Per cent. of fat in milk.
First,	4.54
Second,	4.33
Third,	4.28
Fourth,	4.39
Fifth,	4.38
Sixth,	4.53
Seventh,	4.56
Eighth,	4.66
Ninth,	4.79
Tenth,	5.0[illegible]

(e.) Variation of Time Between Milkings.—As a rule, the longer the time between two successive milkings, the smaller is the per cent. of fat in the milk, and the shorter the time between milkings, the greater the per cent. of fat. When the time between milkings is uniformly equal, the variation of fat in milk is small, provided the general conditions surrounding the cow are the same. However, as there is not commonly such entirely uniform condition of surroundings during the day and night, there is probably a common tendency in the direction of a little more fat in the morning's milk.

(f.) Relation of Yield of Milk to Fat.—Large yields of milk are usually, though not necessarily, accompanied by lower percentages of milk fat, while smaller yields are more commonly associated with larger percentages of fat.

(g.) Influence of Food Upon Amount of Fat in Milk.—This question has been the subject of investigation for years, but we are not yet able to say that we can "feed fat into milk," under ordinary, normal, practicable conditions. It has been noticed by several investigators that a very marked change in the general character

of food, as from an insufficient amount of dry hay to an abundance of nutritious, succulent food, is accompanied by an increase in the percentage of fat in milk, as well as in the yield of milk.

The writer has noticed that, in the case of milk taken to cheese factories, the fat increased very noticeably and generally during the latter half of May, as compared with the preceding portion of the month. In these cases, the cows were commonly fed on timothy hay, without grain, until pasturage came. There was thus a very marked change in the character of the food. However, we cannot deny that the more favorable surroundings of the cows at pasture, as compared with the cows kept in the stable or yard, exerted an influence that should not be overlooked. Taking the milk of quite a large number of different cheese factories we found, on an average, during the first half of May, the per cent. of fat was 3.46, and during the latter half 3.70, an increase of 0.24 per cent. in a brief space of time.

(h.) Variation of Fat in Different Portions of Milk Drawn from Udder.—In the case of the figures given below, the udder was milked as nearly as possible in four equal portions.

	First cow—Per cent. of fat in milk.	Second cow—Per cent. of fat in milk.	Third cow—Per cent. of fat in milk.
First portion,	0.90	1.60	1.60
Second portion,	2.60	3.20	3.25
Third portion,	5.35	4.10	5.00
Fourth portion,	9.80	8.10	8.30

It is seen that in every case the first fourth of the milk drawn from the udder is very low in fat, and that the fat increases in successive portions drawn, until in the last it is extremely high. The most satisfactory explanation offered for this behavior of fat in milking is that the fat-globules strike against the sides of the minute ducts, through which they flow, and the friction thus caused holds the globules back, the milk that remains in the ducts becoming increasingly richer in fat in consequence.

4. The Nitrogen Compounds or Proteids of Milk.

(1.) Number of Proteids in Milk.—So far as our present knowledge goes, we appear to be justified in believing that milk contains not more than four nitrogen compounds or proteid bodies, and these are:

Casein,
Albumin,
Globulin,
Galactase.

Globulin and galactase are present in so small quantities that we can regard casein and albumin as being essentially the nitrogen compounds of milk. These bodies are called nitrogen compounds, because they contain, in addition to other elements, the very important element called nitrogen. These nitrogen compounds of milk or milk proteids can be formed only from proteids received by the cow in the food.

(2.) Milk-Casein.—This is the most important proteid in milk, because it is the one present in largest quantity and also because its presence makes it possible to convert milk into cheese. Milk-casein is most familiar to us in the form of the white, solid substance, or curd formed in milk when it sours, though, strictly speaking, this white substance is not milk-casein but a compound formed by it with acid.

(a.) Casein in Milk Not in Solution.—For a long time it was thought that casein was in true solution in milk; but evidence, produced by different lines of investigation, show beyond question that casein exists in milk in the form of minute, solid, gelatinous particles in suspension. Casein forms a considerable part of separator slime.

(b.) Composition of Casein.—Casein is a very complex chemical compound, containing the elements of carbon, hydrogen, oxygen, nitrogen, sulphur and phosphorus. It is believed that calcium (or lime) compounds are in some way combined with casein.

(c.) Action of Acids on Casein.—Very dilute acids completely coagulate or solidify the casein of milk. In this action the acid forms a compound with casein. If a large amount of acid is added to milk, the casein is first coagulated and then dissolved, as in the case of adding sulphuric acid to milk in the Babcock test bottles. The action of acids in coagulating milk-casein is hastened by increase of temperature.

(d.) Action of Alkalies on Casein.—Such compounds as caustic soda and potash, ammonia, sodium and potassium carbonate, unite with casein and form compounds that are easily soluble in water. They also dissolve the casein that has been coagulated. Some of these compounds are found in commerce as food preparations. Nutrose is a food preparation that consists mostly of sodium casein.

(e.) Action of Other Compounds on Milk Casein.—Certain chemical compounds, when added to milk in large quantities, coagulate casein, such as common salt, magnesium sulphate (Epsom salt), ammonium sulphate, etc. Other compounds, added in smaller quantities, coagulate casein, such as alum, zinc sulphate, corrosive sublimate, formalin, etc.

(f.) Action of Heat on Casein.—Heat alone under ordinary conditions, even at boiling point, does not coagulate casein in milk. The formation of a peculiar skin on the surface of milk heated above 140 degrees F., is largely due to the casein of the milk, and not to albumin, as was formerly supposed. The skin itself contains practically all the constituents of milk and is a kind of evaporated milk.

(g.) Action of Rennet on Milk-Casein.—One of the most characteristic properties of milk-casein is its coagulation by rennet, this property making it possible to manufacture cheese from milk. The curd formed by action of rennet is a compound different from casein and is called paracasein. The coagulation of casein by rennet is quite different from that produced by acids. In connection with the subject of cheese-making, we will consider in detail the properties of rennet and the conditions that affect its power to coagulate with milk-casein.

(3.) Milk-Albumin.—Milk-albumin differs from milk-casein in many ways, the most important of which we will briefly notice. First, milk-albumin is not acted on by rennet; second, it is not coagulated by acids at ordinary temperatures; third, it is coagulated by heat alone, though not completely, above 160 degrees F. From these characteristic differences, it can readily be seen that casein and albumin are very different compounds.

(4.) Galactase in milk was discovered by Drs. Babcock and Russell about five years ago. It is present in very small amounts. It has the power of acting upon milk-casein, first changing it into a solid and then dissolving it. It is believed to be active in cheese ripening.

(5.) Amount of Casein and Albumin in Milk.—In general, the amount of casein and albumin, taken together, are found in milk in quantities ranging from 2.50 to 6 per cent.; the average is about 3.2 per cent. There is about 3.5 times as much casein as there is albumin.

(a.) Casein.—Casein in milk varies from 2 to 4 per cent., and averages 2.50 per cent.

(b.) Albumin.—Albumin in milk varies from 0.50 to 0.90 per cent., and averages 0.70 per cent.

(c.) Influence of Lactation on Casein and Albumin.—There is a very general tendency for casein and albumin to increase in milk as the period of lactation advances, and somewhat more rapidly in proportion than the milk-fat.

5. Milk Sugar.

Milk-sugar is present in cows' milk in solution. In general composition it resembles our ordinary sugar, but its sweetness is very much less than that of cane sugar, and it is also less readily soluble

in water. It is present in milk in amounts varying from 4.5 to 5.5 per cent., and averaging 5 per cent. Its importance in dairy manufacture, especially in connection with butter and cheese, comes from the readiness with which it is converted into lactic acid by various organisms. This action will be studied in detail in the next chapter.

6. The Salts of Milk (or Ash).

The salts of milk, also called the mineral matter, or ash, are important constituents, though they are present in only small quantities, varying from 0.50 to 0.90 per cent., and averaging about 0.70 per cent., as expressed by the ash. The elements which go to make up the salts of milk, stated in the order of their abundance, are the following: Phosphorus, potassium, calcium, chlorine, sodium, magnesium, sulphur and iron. The calcium is probably present in the form of calcium phosphates; the sodium, as sodium chloride; the potassium, as potassium phosphate, chloride and citrate.

7. The Gases of Milk.

Milk contains more or less oxygen and nitrogen, some portions of these gases being carried into it mechanically from the air in the process of milking. It contains also carbon dioxide when freshly drawn, probably between 3 and 4 per cent., a portion of which escapes at once while being milked under usual conditions.

We have now seen, in some detail, how many and what different compounds are contained in milk. There are certain arbitrary divisions of these compounds made for the sake of convenience. One such division makes two classes of the compounds of milk—(1) water and (2) solids, or milk-solids, or total solids, these including fat, casein, albumin, milk-sugar and salts, or ash, of milk. Another division is on the basis of the milk-fat, into (1) fat and (2) milk-serum, this including all the milk except the fat, that is, water, casein, albumin, milk-sugar and ash. Separator skim-milk is nearly pure milk serum. Then, again, the milk-solids themselves are divided into (1) fat and (2) solids-not-fat, the solids-not-fat including the milk serum less the water.

Analyses of Milk.

	Per cent. of water.	Per cent. of total solids.	Per cent. of fat.	Per cent. of casein.	Per cent. of albumin.	Per cent. of sugar.	Per cent. of ash.
Average of 5,552 American analyses compiled by the writer,	87.10	12.90	3.90	2.50	0.70	5.10	0.70
Average cheese-factory milk for the season (May to November) in New York State,	87.40	12.60	3.75	2.45	0.70	5.00	0.70

CHAPTER II.

CONTAMINATION OF MILK.

Milk, on standing, undergoes a variety of changes sooner or later, many of which spoil it for use as food. The most common and extensive changes occurring in milk are due to fermentations. One result of some fermentations is the production of bad flavors, but these may be acquired also either by direct absorption from the surrounding air or from the food consumed. To these different sources of contamination we will now give some detailed attention.

8. What is Fermentation?

The meaning of fermentation can best be made clear by illustration. When a fruit juice, like sweet cider, is allowed to stand at ordinary temperature, it soon begins to undergo changes, large quantities of bubbles of carbon dioxide gas come from the surface of the liquid, and some alcohol is formed. In this case, the sugar of the apple juice is changed into alcohol and carbon dioxide. If this cider, containing alcohol, is allowed to stand long enough at ordinary temperatures, the alcohol disappears, being changed into acetic acid and we then have what we commonly call cider vinegar. The process resulting in the change of the sugar in the cider into alcohol and carbon dioxide is called a fermentation; and that resulting in the change of alcohol into acetic acid or vinegar is also a fermentation.

When milk is freshly drawn, it is sweet, but, on standing a while at ordinary temperature, it becomes sour. The change taking place is the formation of lactic acid from milk sugar, and it is caused by certain germs. The souring of milk is another case of a fermentation.

That which causes fermentation is called a ferment. As there are many different kinds of fermentation, so there are many different kinds of ferments. In the production of alcohol and carbon dioxide from the sugar in cider, the ferment is yeast; in the fermentation of vinegar from alcohol, certain kinds of bacteria are the ferment; in the conversion of milk sugar into lactic acid, certain other bacteria constitute the ferment.

Ferments possess certain general characteristics in common, among which may be mentioned the following: (a) A very small amount of

ferment is capable of producing very great changes. (b) They are all dependent upon temperature as a condition of activity. They cease to act at low and also at high temperatures. Most of them find the temperature best suited to their greatest activity between 80 and 100 degrees F. (c.) Ferments are destroyed by heat, the temperature of boiling water in most cases completely destroying their power to act. Their activity is checked by low temperatures, but, when again warmed, they renew their activity. (d.) The products which ferments form, when accumulating in certain amounts, usually stop further action. (e.) All ferments are closely connected with life processes.

9. Two General Classes of Ferments.

The different bodies that are capable of causing fermentations may be divided into two general classes (1) organized ferments, and (2) unorganized ferments.

(1.) Organized Ferments are living organisms capable of producing fermentations. Those of greatest interest found in milk and its products are called bacteria. Bacteria are the smallest conceivable forms of plant life. Each individual consists of a single cell, averaging in diameter one-thirty thousandth of an inch. They appear in three general varieties of form: Ball (coccus), short rod (bacillus), and cork-screw (spirillum). They multiply in number or reproduce by simple division; that is, when a cell grows in size, it increases more in one direction, so as to lengthen out slightly, and a partition forms across the cell, thus producing two new cells in place of the old one; and then each of these subdivides again and so on continuously. Some kinds of bacteria form spores in the cells; these are to bacteria what seeds are to higher plants. Spores are not so easily killed by heat as are bacteria. Some bacteria have power of motion. Under favorable conditions, their rapidity of growth is remarkable. In some cases, one cell divides into two cells in twenty minutes; if this rate were kept up for twenty-four hours, the one cell would multiply into several millions. Bacteria require as food for satisfactory growth compounds containing nitrogen, carbon, hydrogen, and, in addition, small amounts of inorganic or mineral matter. The sugar, casein and albumin in milk and its products furnish a supply of food very readily utilized by bacteria. As already stated, bacteria are affected by temperature. The bacteria commonly present in milk grow between the limits of 40 and 110 degrees F., the most favorable temperatures being between 80 and 95 degrees F. Many bacteria are killed between 130 and 140 degrees F., when exposed to this degree of heat for ten minutes, and most are destroyed at 185 degrees F. Many spores are killed at temperatures con-

siderably above 212 degrees F., and even then require one to three hours. Dry heat is less effective than moist heat. Live steam, therefore, affords a most efficient means of destroying bacteria. All bacteria are rendered inactive by low temperatures and some may be killed by intense cold. Many bacteria may retain life even on being dried and become active again when placed under favorable conditions of moisture and temperature. Sunlight kills many bacteria when they are exposed directly to the sun's rays for a few hours. Bacteria are either checked in growth or killed by many chemical compounds. Those compounds that simply retard the rapidity of growth of bacteria are called antiseptics; those that destroy bacterial life are called disinfectants. Bacterial activity is stopped by an accumulation of the products formed by it and, in some cases, by the products of the activity of other bacteria. In the course of their growth, bacteria produce great changes in the materials in which they grow, and the processes by which these changes are brought about are known, as previously stated, under the general name of fermentations. Bacteria are found distributed nearly everywhere in the soil, in the air and in water. They are always present in large numbers wherever vegetable or animal matter is undergoing decay. They are, therefore, always closely associated with dirt and filth. While some are the cause of dreaded diseases, most of them are either harmless or actively helpful in many ways.

(2.) Unorganized Ferments or Enzymes are chemical substances or ferments, without life, capable of causing marked changes in many complex organic compounds, the enzymes themselves undergoing little or no change. Many enzymes are produced directly by bacteria, while many are formed in higher plants and in animals. The pepsin found in the human stomach is an enzyme; its special activity enables it to change proteid compounds from insoluble to soluble forms. The ptyalin contained in saliva is another enzyme, and is capable of changing starch into sugar. Babcock and Russell discovered in milk, a few years ago, an enzyme called galactase which has the power of coagulating and then dissolving milk-casein. Another enzyme of interest in dairying is rennet, a small amount of which can coagulate many thousand times its own weight of milk. Enzymes are destroyed by high temperatures and by many disinfectants. Some substances, like ether and chloroform, do not seriously interfere with the activity of enzymes, while they do destroy bacterial activity.

10. Sources of Bacteria in Milk.

Milk, when drawn with careful precautions from the udder of a cow, contains comparatively few bacteria; but milk obtained and

handled under ordinary conditions, is found to contain large numbers, often several hundred thousand in one cubic centimeter (somewhat less than one-quarter of an ordinary teaspoonful). The more dirt there is in milk, the more bacteria there will be. Bacteria and dirt always go together in dairy matters. The bacteria found in milk come from the following sources:

(1) Dairy Utensils. Primarily the milk-pails, strainers and milk-cans. The cracks and joints of all utensils made of tin, unless great care in cleaning is used, contain dirt that holds large numbers of bacteria. Rust and imperfect soldering of joints furnish places for dirt to get out of easy reach. Without prompt and extreme care, strainers easily become filthy and are then simply breeding places for bacteria. When milk cans are used for carrying back to the farm from the cheese factory or creamery whey or skim-milk, the cans often are not cleaned promptly, and, when finally attended to, are not treated with proper thoroughness. Through the medium of a dirty skim-milk tank or whey-vat, filth germs of one form may be distributed throughout the whole neighborhood. Even epidemics of typhoid fever have been traced to this source of infection.

(2.) Udder Cavity.—The milk first drawn usually contains more bacteria than that drawn later. The end of the teat furnishes a good place for bacteria to grow, and some are able, sooner or later, to penetrate upward through the milk duct into the milk cistern and grow there to some extent. The first streams of milk drawn serve to wash out the lower portion of the milk cistern and the duct, and thus carry down bacteria in larger numbers than appear later.

(3.) Bodies of Cows.—The hair on cows favors the accumulation of dirt and dust. The condition is worse in proportion as cows are not regularly and thoroughly cleaned. Dust particles and hairs, laden with bacteria, are in position to drop into the milk pail. While the hairs and coarse chunks of dirt may be removed from milk by straining, the bacteria are, in large part, washed off into the milk and cannot be removed by any ordinary process of straining.

(4.) Milkers.—The hands and clothing of a milker may easily be loaded with bacteria and thus become a source of infection. Particularly objectionable is the filthy practice of some milkers of moistening the hands with milk.

(5.) Air of Stable.—A dirty condition of the floors, walls and ceilings of a stable all tend to contaminate milk. Any condition in the stable that affords a supply of floating dust at the time of milking furnishes additional bacteria for milk.

11. Sources of Contamination besides Bacteria.

While many of the undesirable flavors of milk are due directly to the result of bacterial action, milk may acquire taints that are not dependent on a bacterial origin. Milk, as it comes from a cow, possesses a peculiar "cowy" odor, due to direct absorption of volatile substances within the animal. This odor usually disappears quickly, when milk is exposed to the air; but it becomes abnormal in quality and persistence when a cow eats such things as leeks, turnips, cabbage, rag-weed, etc., a few hours before milking. If milk is not drawn for eight to twelve hours after such food is eaten, such taints either disappear or are greatly diminished. The same experience in milder form may come from the use of some green fodders, such as rape and green rye, and from the feeding of excessive quantities of swill, brewers' grains and distillery slops.

If milk, after being drawn, is exposed to contact with strong odors, such as those coming from manure or other decaying organic matter, or even from ensilage, it readily absorbs them. Milk, whether warm or cold, possesses a very striking power for absorbing and holding volatile odorous substances.

12. Kinds of Bacteria in Milk.

Many different kinds of bacteria have been found in milk. Some appear to be very generally present, others only rarely. Many of them have little or no appreciable effect upon milk or upon human beings; while some furnish products that are distinctly beneficial, others produce only injurious effects in milk, imparting to it bad flavors or unpleasant appearance, and, in some cases, even causing the formation of violent poison. It is also possible that the bacteria causing dread diseases may be found in milk in some instances. We present below the chief classes or types of bacteria that give rise to the fermentations most commonly occurring in milk.

(1.) Lactic Acid Fermentation or Souring of Milk.—The souring of milk is due to the formation of lactic acid, which is produced by the action of lactic acid bacteria upon the sugar in the milk. In this form of fermentation, one can begin to taste the acid when it amounts to about 0.3 per cent. of the milk. As the amount of acid increases to 0.4 per cent., the milk begins to curdle or thicken, and, as the amount of acid increases above this, the curd becomes more solid. These bacteria continue actively converting milk sugar into lactic acid until the acid reaches 0.8 to 1 per cent. of the milk, and then they cease their activity, because they cannot live in a solution containing this amount of acid. Their activity is stopped by the accumulation of the product of their own activity

and not because the supply of milk-sugar runs out, for, when they cease their activity, about three-quarters of the milk sugar still remains unconsumed. There are several different kinds of bacteria that can convert milk sugar into lactic acid. The temperature most favorable to the growth of lactic acid organisms in 90 degrees F. to 95 degrees F. Below 80 degrees F. they gradually lose their activity and practically cease at 50 degrees F. At 105 degrees F. they are fairly inactive, many are killed at 135 degrees F. to 140 degrees F., and at 150 degrees F. to 160 degrees F. all are killed. While this fermentation spoils milk for the taste of most people, it is a very essential factor in the manufacture of butter and cheese, as will be seen later. It is quite commonly thought that milk is peculiarly liable to sour during thunder storms, as the result of some peculiar electrical or other influence. The hot weather preceding such storms favors the more rapid growth of the lactic acid germs, and this is the proper explanation. Milk free from such germs never sours during thunder storms.

Some of the bacteria that act upon milk-sugar form large quanities of gases, especially carbon dioxide and hydrogen, and these gases are responsible in cheese-making for "floating" curds and "huffing" cheese.

(2.) Fermentations Affecting Milk-Casein.—Occasionally milk curdles without souring. This is caused by the action or rennet-like enzymes or ferments which certain bacteria produce. The same bacteria usually produce a second enzyme, which dissolves the coagulated casein. Some bacteria form only the dissolving or digesting enzyme, in which case the casein is slowly rendered soluble without previous coagulation. The bacteria that affect casein do not grow in the presence of lactic acid, and as the lactic acid bacteria usually develop more rapidly, they soon stop the growth of the former In the absence of lactic acid bacteria, the digesting organisms are apt to grow. There are other forms of fermentation that act upon milk-casein and result in the production of substances having extremely offensive odors and disagreeable taste. In some cases poisonous products are formed, as, for example, tyrotoxicon, commonly known as cheese poison.

(3.) Butyric Acid, or "Rancid" Fermentations.—Some organisms act upon milk-fat or butter-fat, forming free butyric acid, thus producing the odor and taste of "rancid" butter. These bacteria grow slowly under ordinary conditions and do not commonly become active in milk, unless kept a long time, but they find their way into butter and, under favorable conditions, develop there to the disadvantage of the flavor of the butter.

(4.) Less Common Forms of Fermentation in Milk.—The kinds of bacteria described above are found commonly occurring in milk, but there are others which appear only occasionally, and some of these will now be briefly considered.

Most dairymen sometimes have milk that fails to sour or curdle, but after a few hours begins to be slimy and finally can be drawn out in long threads. This condition more commonly appears in cream. The trouble may be due to diseased udder, in which case it is apparent at once when the milk is drawn. The form which does not appear at once after milking is due to bacteria. Other abnormal forms of fermentation in milk result in producing alcohol, bitter milk, soapy flavor, fishy flavor, red, blue and other colors.

(5.) Disease Germs in Milk.—Milk furnishes a medium in which many disease germs can readily develop. Some disease-producing bacteria are capable of being transmitted directly from a diseased cow to a human being through the milk. It is quite generally believed that if milk is taken from a cow suffering with tuberculosis in the udder, it will be fairly sure to contain tuberculosis germs; and such milk taken into a human body may produce tuberculosis. Other disease-producing bacteria may get into the milk after it is drawn, having nothing whatever to do with the cow. Such are germs causing typhoid fever, scarlet fever, diphtheria and diarrhoeal diseases, such as cholera infantum. Such disease germs may get into milk from a case of illness on the premises where the cows are milked, through the carelessness and ignorance of the members of the household.

CHAPTER III.

PREPARATION OF MILK FOR MARKET.

In the preceding chapter we have seen that bacteria of different kinds get into the milk in various ways and, under conditions favorable to their activity, cause fermentations that may result in rendering milk totally unfit for sale. Therefore, the chief aim to be kept in mind in preparing milk directly for market is practically this, how to keep under control the growth of bacteria to such an extent that injurious fermentations shall not take place to any marked degree. Three general methods are in use for securing control of fermentations in milk: (1) Keeping bacteria from getting into milk, (2) preventing growth of bacteria already in milk, and (3) destroying bacteria already in milk. We will now consider these methods separately.

13. Keeping Bacteria from Getting into Milk.

We have previously seen that the common sources which are responsible for furnishing the bacteria that are found in milk are (1) the air of the stable, (2) the body of the cow, (3) the person of the milker, and (4) the dairy utensils with which the milk comes into contact. We have also seen that the one common source of bacteria in all these cases is dirt. Hence, the one thing needful to prevent bacteria getting into milk is extreme cleanliness at every point of contact with the milk. The following suggestions are given to indicate what is meant by cleanliness in connection with milking and caring for milk.

(1.) The Stable.—Every condition about the stable should be regulated with reference to absence of dirt, an abundant supply of pure air, and a direct exposure to sunlight. The floors should be tight and of a material not readily absorbing liquids. An abundance of clean bedding should be used, and the manure should be removed more frequently than once a day, and, in any case, not immediately before milking. The walls and ceiling should be swept often enough to prevent the accumulation of dust. Once a year, at least, it is wise to clean the whole stable with extreme care and then go over the whole with a generous coat of whitewash. At such a time, the stable should be thoroughly disinfected, if there have been any contagious diseases in the stable. The surroundings outside of the stable should be kept in a clean condition, so as not to interfere with the supply of pure air.

(2.) The Body of the Cow.—Too much pains cannot be taken to keep the cows clean. In addition to regular currying and brushing all over, the udder and adjacent portions of the body should be carefully brushed before milking and also wiped with a damp, clean cloth. The udder should also be wiped after milking.

(3.) The Milker should wash his hands carefully before milking and have them perfectly dry while milking. It is also desirable to have a special coat or jacket for milking, made of some material that will not catch or hold dust easily.

(4.) The Dairy Utensils.—All utensils that come in contact with the milk, such as milk-pails, milk-cans, aerators, etc., should be made of metal, preferably of pressed tin, with smooth, well-flushed joints and perfect seams. They should be kept entirely free from rust. Such vessels should never be allowed to dry when dirty, as dried particles of milk are particularly difficult to remove. In cleaning dairy utensils, rinse them first with lukewarm water and then wash them thoroughly in hot water, using soap or washing soda. Then rinse them with hot water and complete the cleansing, if possible, by exposing to a jet of live steam for three to five minutes.

When practicable, expose them finally to direct sunlight for a few hours. Strainers should be washed immediately after using, cleaning first in tepid water, following with hot water and soap and finally with hot water and steaming or boiling.

(5.) Time of Feeding.—Foods having marked odors should be fed only after milking and then at once, and none should be left in the stable. Dry fodders, which furnish dust, should likewise be fed after milking.

(6.) Diseased Milk.—The milk of diseased animals should not be used nor that of animals fresh in milk before the ninth milking.

(7.) Contagious Diseases.—No person suffering from, or recovering from, a contagious disease, nor any person that has anything to do in caring for such a person should be allowed to have any contact with the dairy.

(8.) Removal from Stable and Subsequent Treatment.—As soon as each cow is milked, the milk should be removed from the stable to some room free from all bad odors and with cleanly surroundings. The milk should be at once strained through a brass-wire strainer, having not less than fifty meshes to the inch, and also through three or four thicknesses of cheese-cloth. Still more effective results in straining can be secured by the use of absorbent cotton, though its expense makes its use impracticable under ordinary conditions. After straining, cool to 50 degrees F., or below.

By observing precautions like these, it is easily possible to reduce the number of bacteria in the milk to such an extent that the milk will keep eighteen to twenty-four hours longer than ordinary milk. Precautions like the foregoing for keeping bacteria out of milk are practicable, where one owns a herd of cows and has all conditions under personal control; but it is another matter when it comes to making some one else observe them. So, when milk is not under one's control, the next best thing is to prevent the growth of the bacteria already in the milk, and this may be done by use of low temperature in keeping the milk or by heating the milk first and then cooling. One method prevents or delays the growth of bacteria without destroying the germs themselves, while the other destroys most of the bacteria.

14. Preventing or Delaying Growth of Bacteria in Milk.

Whether precautions have been taken or not to keep large numbers of bacteria from getting into milk, it is necessary, as soon as milk is drawn, to cool it quickly, and the lower the temperature, the better. At temperatures below 50 degrees F., the rapidity of growth of the bacteria is greatly lessened. In connection with the cooling

of milk, it is well, at the same time, to aerate it, in order to remove the natural "animal" odor or any other odor that may have been absorbed by the milk after milking. There are several special forms of aerators in the market (see Figs. 1 and 2) that serve for both cool

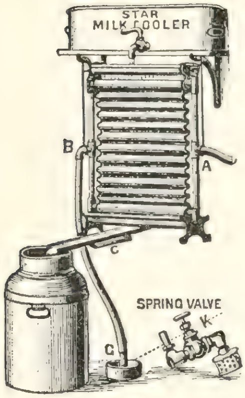


Fig. 1.

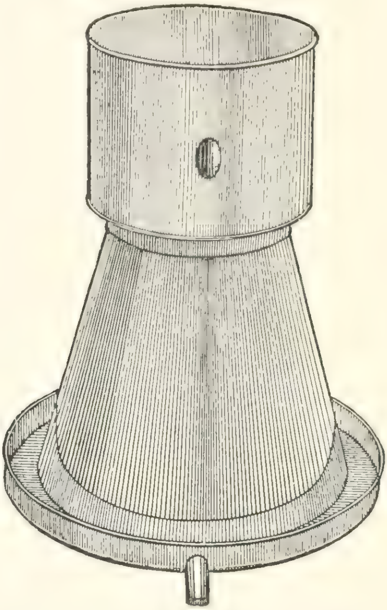


Fig. 2. Champion cooler and aerator.

ing and aerating the milk at the same time. The main points to be considered in selecting an aerator or a combined aerator and cooler, are simplicity of construction, ease of management, effectiveness in cooling and aerating and convenience in keeping clean. Aeration must always take place in an atmosphere as free as possible from bacteria; otherwise the process will only increase the number. The use of low temperatures in keeping milk gives the best results only with the milk that is most free from bacteria.

15. Destroying Bacteria in Milk.

In the case of milk that contains large numbers of germs, the most effective way to keep the milk from souring and from the development of other forms of fermentation is to destroy the bacteria. This may be best accomplished by heating the milk. While it is possible to add to milk chemicals that will destroy bacteria without affecting the composition or taste of the milk, the use of preservatives is very generally condemned for this purpose on the ground that they may injuriously affect the health of people using milk

thus treated. The use of preservatives, such as salicylic acid, boracic acid, formalin, etc., for the purpose of keeping milk is not to be recommended. In employing heat to kill bacteria, two general methods have been used, known as pasteurizing and sterilizing.

(1.) Pasteurizing Milk.—In pasteurizing milk for market, it is heated to 140 degrees F., and held at that temperature for twenty or thirty minutes. Formerly, higher temperatures were used, but it was found that milk, heated above 156 degrees F. acquired a "cooked" taste and that the cream did not readily rise. While the lower temperature does not destroy all germs, it destroys most of them and greatly improves the keeping power of milk. To secure best results in pasteurizing, it is desirable to use milk as fresh as possible. Milk containing 0.2 per cent of lactic acid does not give good results. The fewer bacteria milk contains before pasteurizing, the better will be the results of pasteurization. It is also very essential in pasteurizing that the heated milk should be cooled down at once to 50 degrees F., or lower. It should also be stored in germ-free bottles or other vessels and kept cold until it is delivered to the customers. When used by children, pasteurized milk should be consumed within twenty-four hours after treatment. If pasteurization is properly carried out, the milk should remain sweet, even at ordinary temperatures, one and one-half to two days longer than ordinary milk not so treated.

There are on the market several forms of machines for pasteurizing milk. The best machine should possess the following qualifications: (a) Compact form, (b) ease of keeping clean, (c) complete control of temperature, (d) ability to heat milk quickly, completely and uniformly, (e) freedom from liability of additional germs getting into the milk during the operation of pasteurizing.

The pasteurization of milk has the following advantages: (a) It increases the keeping quality of milk. (b) It destroys disease-germs, especially those of tuberculosis. (c) The taste and digestibility of milk are not changed. (d) The process is practicable on a large or small scale.

(2.) Sterilizing Milk.—In order to render milk absolutely free from all bacteria and their spores, it is necessary to heat milk above 212 degrees F. for an hour on each of three successive days, thus giving all spores a chance to develop into active forms, which are then more readily killed. Simple boiling is effective in destroying practically all living disease-germs. Sterilized milk is objectionable for several reasons: (a) It has the characteristic taste of "cooked" milk, which is unpleasant to most people. If people had only sterilized milk to drink, very much less would be used. (b) Sterilized milk appears to be less digestible, especially in the case of children and invalids.

CHAPTER IV.

CREAM.

16. Composition of Cream.

Cream is the fluid product, rich in milk-fat, obtained by removing milk-fat from milk in any manner, along with some portions of other milk constituents. Cream contains the same constituents as milk, but in very different relative proportions. Cream contains much more fat than does milk, but less of the other constituents. Cream varies greatly in its fat content, ranging all the way up from 10 per cent. or less. Market cream often contains less than 15 per cent. of fat, but good cream for domestic use, at the prices commonly charged, should contain 20 to 25 per cent. of fat. The amount of fat in cream depends upon a variety of conditions, but chiefly the method employed in removing the cream from the milk. For illustration, we give the composition of several different samples of cream in the following table:

Per cent. of water.	Per cent. of fat.	Per cent. of casein and albumin.	Per cent. of sugar.	Per cent. of ash.
76.60	15.0	3.1	4.5	0.6
66.30	25.0	3.2	4.8	0.7
62.40	31.5	2.6	3.0	0.5
39.40	56.0	1.6	2.3	0.4

In the separation of cream, the individual fat-globules are not in any way affected; they are simply crowded together in less space than in milk.

17. Separation of Cream.

The fat-globules in milk are relatively lighter than the milk-serum, in which they float free in the form of an emulsion. When milk is permitted to remain quiet in a vessel, the fat tends to rise and accumulate at the surface of the liquid, owing to its lighter specific gravity, relative to milk-serum. In thus passing up through the milk, the fat-globules mechanically carry with them some of the milk-serum. Until recent years, cream was all produced by allowing the fat-globules to separate by gravity, but there have come into gradual use machines that are used to separate cream from milk

by means of centrifugal force. Hence, we have in use two general methods of cream separation, (1) the gravity system, and (2) the centrifugal or separator system.

18. Gravity Method of Cream Separation.

The gravity method of cream separation has been used in two different forms, one known as the "shallow-pan" system and the other as the "deep-setting" system.

(1.) Cream Raising by Shallow-Pan System.—This is the oldest method employed in separating cream from milk. It is still employed in many small dairies. To obtain the best results with this method, the milk should be placed in the pans at once after milking and should be cooled to 60 degrees F. within a reasonably short time, and should then remain quiet at about that temperature for thirty-six hours or more. The depth of milk in the pan may be from two to four inches. When cold running water can be used to surround the pans ,the depth may be from four to six inches. Ordinarily a cool, clean cellar, well ventilated, furnishes good conditions. Any place where the milk can be exposed to bad odors or to dust should be avoided. There are some serious objections to this method of creaming, among which may be mentioned (a) exposure of a large surface of milk to air for a long time, thus giving unusual opportunity for bacteria to get into the milk; (b) a temperature permitting the rapid increase of bacteria by growth; (c) incomplete separation of fat-globules from the milk serum; (d) wasteful loss of cream in skimming; (e) drying out of cream, making it liable to go into butter in dried chunks and injure the texture. (f) The amount of acid in the cream is apt to become too great, thus injuring the flavor of the butter. It has been found that skim-milk obtained by the shallow-pan system of creaming seldom contains less than 0.5 per cent. of fat, while the average of actual practice is much higher, amounting to about one-fifth of the entire fat present in the milk.

(2.) Cream Raising by Deep-Setting System.—This method has been in use between thirty and forty years, probably reaching its most extensive use ten years ago. It was found that by using long pails or cans, not more than a foot in diameter, and placing these, filled with fresh milk, in a tank of water kept at 40 degrees F., the cream would separate more completely and in much less time than it would when raised in shallow pans, twelve to twenty-four hours being sufficient for the separation. This system is capable of reducing the loss of fat in skim-milk to 0.2 per cent., when the most

favorable conditions are present. This method also has the advantage of greatly diminishing the amount of exposure to air, thus preventing additional bacteria getting into the milk from the air during the creaming process. Owing to the low temperature employed, the growth of bacteria in the milk is greatly retarded. To use this system satisfactorily, ice is necessary. The cream raised by the deep-setting method is not very rich, usually containing between 15 and 20 per cent. of fat.

In the gravity method of cream-raising, the rapidity and completeness of separation of cream are dependent upon several different factors, among which may be mentioned (a) the size of the fat-globules, (b) the amount of solids in the milk-serum (the solids-not-fat), and (c) the relative proportions of the different solids in the serum. The larger fat-globules separate from the milk more quickly than the smaller ones do. The size of fat-globules varies with individual cows, with breeds, with advance of the period of lactation, and with other conditions. The fat-globules in the milk of cows fresh in milk are larger than later in the lactation period, decreasing in size as the cow is farther from the beginning of her period of lactation. The solids-not-fat in milk, that is, the casein, albumin, sugar and mineral salts cause milk to have the property of what is called *viscosity;* by this is meant the power of adhering to other solid things. The presence of these solids in milk gives milk the power of adhering to fat-globules, thus offering resistance to their tendency to rise or move in any direction. Now, the greater the amount of these solids not-fat in milk, the more opposition do the fat-globules have to overcome in rising, and the more slowly and incompletely does such milk cream. It is well known that, as a cow gets farther along in her lactation period, the casein and albumin increase more rapidly than do other constituents and they greatly increase this viscosity of the milk. Hence, with advance of lactation, we have two different factors increasing all the time in the milk that interfere with the raising of the cream, viz: decrease in size of fat-globules and increase of viscosity. This explains why the gravity method of creaming gives less satisfactory results when a cow is far along in milk than when she is fresh. To overcome these adverse conditions, various expedients have been tried, the most common being dilution of the milk by water, both warm and cold. The advantages secured in this way are doubtful and the disadvantages accompanying such a practice are considerable.

19. Separation of Cream by Centrifugal Force.

It is not our purpose to discuss the details of the mechanism of centrifugal machines or to describe the different varieties in the market. We intend simply to make a few statements in regard to

the general principles applying to their use and the results secured. There are on the market many different forms of these machines, and between many of them there is very little choice in respect to their relative efficiency. If any one, not well informed about separators, plans to purchase one, it is suggested that it would be desirable to correspond with the Experiment Station at State College and obtain authoritative advice in regard to the qualities of different machines rather than to rely wholly upon the persuasive statements of agents who are ambitious to sell machines.

All centrifugals designed for separating cream from milk are based upon the same general principle. The milk enters a rapidly whirling bowl and at once partakes of the centrifugal motion, being thrown by the centrifugal force to the extreme wall of the bowl. As the milk continues to flow in, the bowl fills from the outside toward the center. The centrifugal force acts more strongly upon the heavier portion of the milk, that is, the milk serum or all the milk except the fat. Hence, the milk-serum is forced to the outside wall of the bowl, while the lighter portion of the milk, the fat with some adhering serum, is forced to the center. Tubes connect with the skim-milk layer at the outer wall and with the cream layer at the center of the bowl to carry away these products as they accumulate. The outer walls of the separator bowl gradually become covered with some of the solid, heavier constituents of the milk, including solid dirt present in the milk, forming what is known as "separator slime," the composition of which we will notice later.

(1.) Conditions Affecting Creaming Efficiency of Separators.—The efficiency with which separators remove cream from milk depends upon several different conditions, some of which we will briefly consider.

(a.) The intensity of centrifugal force affects the efficiency of a separator. This increases as the diameter of the bowl increases and also when the bowl whirls rapidly. So, the larger the bowl, and the greater the speed of the bowl, the greater is the centrifugal force and also the creaming efficiency.

(b.) The rate at which the milk flows into the separator bowl affects the creaming efficiency. The more slowly the milk flows in, the longer it is under the action of the centrifugal force and the more completely is the fat removed from the milk.

(c.) The temperature of the milk when run through the separator affects the creaming efficiency. The warmer the milk, the more easily the fat separates. The temperature commonly employed is from 76 to 98 degrees F. In producing cream for butter-making, the milk should be separated at as low a temperature as possible without diminishing the creaming efficiency, because heating

the fat-globules above a moderate temperature tends to produce butter of soft texture.

(2.) Regulating Richness of Cream.—The richness of cream produced by a separator is regulated by the rate at which the milk flows into the bowl and by the rapidity with which the bowl revolves. The more rapid the inflow of milk or the slower the speed of the bowl, the larger the quantity of cream and the poorer in fat. Most machines are provided with special arrangements for regulating the richness of cream without changing the rate of inflow or rapidity of motion.

(3.) Creaming Efficiency of Separators.—A good centrifugal separator should not leave more than one-tenth of one per cent. (0.1 per cent.) of fat in the skim-milk, when it is run under proper conditions.

(4.) Promptness in Separating Milk.—Milk should be separated as soon as practicable after milking, and the cream should be cooled down to 50 degrees F., or below.

(5.) Advantages of Creaming by Centrifugal Machines.—Among the advantages that may be mentioned in favor of employing centrifugal machines in separating cream from milk are the following:

(a.) There is a great saving of fat. Gravity systems of creaming leave, on an average, 0.5 per cent. of fat or more in the skim-milk, while good separators properly handled should not leave more than 0.1 per cent. In a large number of comparative experiments made by the writer, where milk from different breeds of cows was creamed both by the deep-setting gravity system and by centrifugal machine, it was found that the separator effected a saving of fat amounting to twenty-four to sixty-five pounds a year for each cow. In the form of butter, at twenty cents a pound, this saving for each cow would be equivalent to $5.00 to $15.00 a year.

(b.) In the case of cream separation by the gravity system, the composition of the cream is not under satisfactory control, and will vary, even under the most uniform conditions of creaming, 5 per cent. of fat or more. One can never be sure in advance of what the fat content of gravity-raised cream will be. In the case of cream separated by a centrifugal machine, one can so regulate the conditions as to produce cream with just the desired amount of fat in it. It is thus easy to produce a product that is uniform in composition, since the conditions are under easy control. In the case of producing cream for sale as such, it is very important that the product shall be uniform from day to day.

(c.) Separator cream is more free from dirt and bacteria and will keep longer than will gravity cream. Most of the dirt in milk in the form of solid particles is completely removed by the centrifugal separator, as the appearance of the separator slime abundantly testifies.

(d.) The skim-milk produced by separator creaming is sweeter and more free from bacteria and dirt than that produced by gravity creaming. Separator skim-milk is, therefore, better for feeding purposes.

20. Artificial Thickening of Pasteurized Cream.

When cream is prepared to sell for immediate consumption as cream, its keeping power can be very greatly increased by pasteurizing at 140 degree F., without affecting its taste. However, some of the physical properties of the cream are so changed by pasteurizing that it appears thinner after pasteurization, though containing the same amount of fat. Pasteurized cream, therefore, gives the impression of being poorer in fat, and is much more difficult to make whipped cream from. Babcock and Russell have devised a simple, effective and absolutely harmless method of restoring the proper consistency or body, to pasteurized cream. This consists in the addition of a small amount of "viscogen," which is an entirely harmless compound made from lime-water and ordinary granulated sugar. Viscogen is prepared as follows: Take two and one-half parts, by weight, of granulated sugar and dissolve in five parts of water. To this add some lime-water prepared thus: To one part of quick-lime add three parts of water, stir thoroughly until the lime is completely slaked, strain and this liquid, which is simply lime-water, is added to the solution of cane sugar. The mixture of lime-water and cane sugar is shaken or stirred at intervals for two or three hours, after which it is allowed to stand until settled. Then the cleared liquid is poured off and stored in tightly-stoppered bottles ready for use. Of this liquid, thus prepared, add one ounce to three gallons of cream and stir thoroughly. Sometimes a little more is needed. As many States have stringent laws against the addition of any kind of foreign substance to milk or cream, cream to which viscogen has been added should not be sold as simple cream, but as a special preparation of cream. Moreover, customers should be given the choice of buying cream with or without viscogen, as some people have a prejudice against additions of any kind to their dairy food products. However, the use of viscogen is just as harmless to health as the use of so much common salt.

21. Profits Derived from Selling Cream.

There is no form under which milk can be sold at so great a net profit as in the form of cream. The labor involved and the cost of preparation are much less than in the case of making butter or cheese. The skim-milk may all be kept on the farm, while in the

case of milk-selling and cheese-making there is none. At the market rates commonly prevailing for dairy products, the price received for cream is higher, relative to its cost of production, than is the price of an equivalent amount of milk, butter or cheese. An investigation made by the writer some years ago indicated that the net profit from selling cream is nearly three times that from butter, nearly four times that from selling milk and about seven times that from selling cheese. While the demand for cream is limited, it has been steadily increasing. Any dairyman, so circumstanced that he can dispose of his milk in the form of cream directly to customers, should make an effort to develop this form of trade.

22. Composition of Skim-Milk.

Skim-milk is the product, containing water and milk-solids that remains when any portion of fat normally present is removed from milk in the form of cream by any means whatever. It is essentially milk-serum with some milk-fat in it. Skim-milk varies in composition according to the composition of the milk before skimming, and according to the method of creaming.

(1.) Difference in Composition of Gravity and Separator Skim-Milk. —Separator skim-milk differs in composition from gravity skim-milk chiefly in the amount of fat present. The following figures serve as a good illustration to show the difference in such composition:

	Gravity skim-milk — Per cent.	Separator skim-milk—Per cent.
Water,	90.00	90.30
Fat,	0.50	0.10
Casein and albumin,	3.50	3.55
Milk-sugar,	5.20	5.25
Ash,	0.80	0.80

(2.) Difference in Composition of Skim-Milk from Different Kinds of Milk.—We will illustrate next the difference in composition of skim-milk due to difference in composition of the original milk before skimming. For this purpose, we will consider only the total solids of the milk, as this will sufficiently illustrate the point we

wish to bring out. We will assume that each of the milks represented is creamed by a separator and that all of the fat but one-tenth of one per cent. is removed:

	Per cent. of total solids in milk.	Per cent. of fat in milk.	Per cent. of total solids in skim-milk.
Milk No. 1,	11.80	3.30	8.90
Milk No. 2,	12.65	3.60	9.50
Milk No. 3,	14.50	4.60	10.50

There has been common an idea that the skim-milk from milk rich in fat is of inferior quality to skim-milk from milk less rich in fat. The figures above show that this idea is erroneous. The richer a milk is in fat, the richer it is in solids-not-fat, that is, skim-milk solids. A hundred pounds of skim-milk from rich milk contains more casein, albumin and milk-sugar, as a rule, than will a hundred pounds of skim-milk less rich in fat, provided, of course, that the method of removing fat is the same.

Some writers have made a distinction in name between skim-milk obtained by the gravity process of creaming and that obtained by the separator process, calling only the former skim-milk, and applying the term "separated milk" to separated skim-milk. The distinction is without justification and quite uncalled for, since skim-milk is the product left after removing fat from milk, without reference to the method employed in removing the fat.

23. Valuable Uses of Skim-Milk.

Skim-milk has come to have a variety of uses, giving it a definite value. To the dairy farmer, the most valuable use to which he can put skim-milk is, undoubtedly, as food for animals. The composition of skim-milk, as given above, shows considerable quantities of casein and albumin and milk sugar, all of which are important food constituents in forms readily digestible. Skim-milk should preferably be fed sweet, as some of the sugar is lost by fermentation, and marked acidity does not always agree with the digestion of young animals. Skim-milk may be fed to advantage in connection with other foods to all kinds of farm animals.

Skim-milk is also a valuable food for human beings, both in the form of a beverage and in cooking. It should be used much more extensively than it is. Unfortunately, dishonest milk dealers have tried fraudulently to sell skim-milk as whole milk, so that the sale of skim-milk has to be attended with annoying restrictions.

Skim-milk is also used in considerable quantities in the manufacture of cottage-cheese.

The casein of skim-milk is used for a variety of purposes, among which may be mentioned, its use as sizing or dressing in the manufacture of paper as a substitute for celluloid, and as a constituent of plastics for a great variety of purposes.

24. Composition of Separator-Slime.

The separator-slime, which collects on the walls inside the separator-bowl, consists largely of milk-casein, in which are collected all kinds of solid impurities contained in the milk, such as dust, fine particles of hay, ground grain, dung, cow hairs, etc. It is heavily loaded with bacteria. The chemical composition of separator-slime is about as follows:

	Per cent.
Water,	67.0
Fat,	1.0
Casein,	26.0
Milk-sugar,	2.0
Ash,	4.0

On an average, 2,500 pounds of milk produce one pound of separator slime. The amount increases with the amount of dirt present in the milk.

CHAPTER V.

BUTTER-MAKING.

In taking up the subject of butter-making, we assume that we have the cream to start with. The question is sometimes asked why it is necessary to remove cream from milk for butter-making, why not churn the milk itself? Experiments in churning milk have never succeeded in removing the fat from the milk at all completely and the method results in large losses of fat with consequent decrease in yield of butter.

In the case of cream that has been separated by a centrifugal machine, it is important to cool the cream to 50 degrees F. or below, without delay, and to hold it at this temperature for six or eight hours. This cooling appears to be important, in order to obtain butter with sufficiently firm texture. In general, it may be said that we shall be most successful in making butter having the best texture, when the milk and cream are subjected to the fewest changes of temperature and when the changes of temperature that are needed are made in the most gradual, uniform manner.

After having the cream in the condition indicated above, we perform the following different operations in making butter:

(1.) Ripening the cream.
(2.) Churning.
(3.) Washing and working.
(4.) Salting.
(5.) Packing.

After considering the composition of butter, we will take up, in their proper order, the different operations required for making butter.

25. Composition of Butter.

The composition of butter varies considerably, according to the methods and conditions of manufacture. The principal variations are in the fat and water. The following tabulated statement serves to give an idea of the usual limits of variation in composition of American butters, but there are extreme cases lying outside the limits here given:

Per Cent. in Butter.	Low.	High.	Average.
Water,	10.0	15.0	13.0
Fat,	80.0	85.0	83.5
Casein,	0.5	2.0	1.0
Ash (salt),	1.0	4.0	2.5

Good commercial butter should contain over 80 per cent. of fat, and not more than 15 per cent. of water or 3 per cent. of casein.

26. Ripening Cream for Butter-Making.

The ripening of cream is essentially the process of developing enormous numbers of certain kinds of bacteria in cream, the most prominent ones in point of numbers and visible activity being lactic

acid bacteria. When butter is made in the old way, the cream is allowed to stand until it ripens spontaneously, no attempt being made to control the process. As the result of the fermentations that occur in the ripening process, many complex changes take place in cream, the details of which are not fully understood. The most obvious results brought about by cream-ripening may be included under three general heads; (1) The formation of lactic acid, (2) the development of products that have charactertistic odors, and (3) the formation of substances that yield a characteristic taste on the tongue. To what extent these effects are produced by special organisms, we have little detailed knowledge, aside from the work of lactic acid bacteria in producing lactic acid. The real sources of the flavors of ripened cream we do not know specifically, nor do we know what these specific compounds are that give rise to the flavors. The amount of lactic acid formed is used as a measure of the extent or degree of cream-ripening, but other forms of fermentation are known to be present at the same time, at least during the early portion of the ripening process. Butter may be made from cream that has not been ripened at all, that is, from sweet cream, or it may be made with the help of artificial acid added to cream, but in neither case do we make a product that is in flavor like butter made from ripened cream.

27. How Lactic Acid is Produced in Cream Ripening.

In order to have the lactic acid fermentation of cream ripening, lactic acid bacteria must be present in the cream and the cream must be kept at a temperature favorable to their growth. We may leave the cream to receive the bacteria by chance, or we may introduce them into the cream purposely. In the old-style method of butter-making, the former method is employed. We have already seen (section 12, p. 567), that milk nearly always contains lactic acid bacteria. During the operation of creaming, these bacteria usually develop to such an extent that, when the cream is exposed to higher temperatures, fermentation proceeds rapidly. However, under such circumstances, the rate of fermentation is not uniform in different lots of cream; at one time more lactic acid is formed, and at another less, during a given time, because the number of bacteria will inevitably vary greatly when their introduction is left to chance.

The formation of lactic acid can be controlled in respect to time and quantity, when we introduce the lactic acid bacteria purposely in sufficient quantities. Material, containing large numbers of lactic acid organisms, which is used to add to milk or cream for the purpose of causing lactic acid fermentation, is known as a "starter." There are two varieties or sources of starters, (1) natural, and (2) pure cultures.

(1.) Natural Starters.—Among the materials used as natural starters in butter-making are buttermilk and cream from previous operations of butter-making, and whole milk or skim-milk soured under special conditions. While there are different ways of preparing natural home-made starters, the following method may be suggested as one that will give good results, if properly carried out: Milk is taken from a cow in perfect health, not too far along in lactation, and kept under proper conditions of cleanliness. The udder and under parts of the cow's body are brushed and then wiped with a damp cloth, after which the cow is milked into a carefully cleaned vessel, the first few streams of milk from the udder being thrown away. The milk thus drawn is at once covered, taken to the dairy and run through the separator. This skim-milk, put into a carefully cleaned receptacle, is carefully covered, brought to a temperature of 90 degrees F., after which it is placed where it will keep at a temperature of 65 degrees F. to 70 degrees F. In twenty to twenty-four hours, the skim-milk will be found properly ripened or just moderately thickened. In using this prepared starter for ripening cream, the upper portion to the depth of one or two inches is removed and thrown away, the rest is strained through a fine strainer or hair seive into the cream, which should be at 70 degrees F., in the proportion of two pounds of starter for 100 pounds of cream. The starter should be thoroughly stirred into the cream, the cream vat covered and kept at a temperature of 65 degrees F. to 70 degrees F. Usually twenty-four hours will develop the proper amount of acid for churning. When the cream is properly ripened, it should just form a soft curd, not a hard curd. In case of over-ripening, when the curd becomes too hard, there is danger that some of this coagulated casein will get into the butter and injure its quality and appearance. Some of this prepared starter, described above, may be used in preparing a starter for the day following, putting a little into skim-milk that has been heated to 180 degrees F. for thirty minutes and then cooled down to 70 degrees F., and the starter may thus be propagated from day to day; but this method of propagating must not be continued too long, as the starter gradually becomes inoculated with undesirable forms of bacteria and sooner or later is unfit for use. These natural starters may be used in either pasteurized or unpasteurized cream.

(2.) Pure-Culture Starters are special preparations consisting of certain specific selected organisms, known to be adapted to the work of cream ripening. There are on the market several different preparations for ripening cream, consisting of special cultures. Such commercial artificial ferments give the best results, when used in pasteurized cream. The chief advantage found by experience to

come from the use of these pure culture starters is uniformity in character of the butter produced and better keeping quality. Full directions for methods of use always accompany these special starters and we do not need to consider them here.

28. Amount of Acid Needed for Cream Ripening.

The ripening of cream was, for a long time, the most difficult step of butter-making to control, and the specially difficult point in this operation was to determine the amount of acid that should be present before churning. The appearance, odor and taste of the cream are guides, to some extent, as to the amount of acid formed, but they are far from reliable for accurate, uniform work. It is very important that the same amount of acid shall be developed from day to day in order to secure butter of uniform quality. When cream is ripened so as to show a test of five-tenths to six-tenths of one per cent. of lactic acid, it produces a higher flavored butter than that produced by cream ripened to four-tenths of one per cent. of acid. When cream contains more than sixty-five hundredths of one per cent. of acid, the flavor of the butter is too strong. Moreover, in such cases, the particles of coagulated casein become very hard and form white specks in the butter. Such butter acquires bad flavors quickly. The whey should never separate from the curd in cream ripening. We now have an inexpensive, simple method for determining the amount of acid in cream, and, while the method is not strictly accurate, it is sufficiently close for all practical purposes in cream ripening. For careful work in butter-making, this method of determining the amount of acid in cream should always be used. The method is fully described in section 90, p. 653, Chapter XI.

29. Effects Produced by Cream Ripening.

The effects of cream ripening are seen in several different ways, among which we will notice the more important.

(1.) Improved Flavor of Butter.—In order to secure butter with the kind of flavor required by the average consumer, it appears to be necessary to ripen cream. This is probably the most important and far-reaching effect of ripening cream. The importance of flavor in butter is easily obvious, when we consider that flavor more than any other factor determines the market price of butter. Poor cream ripening means poor flavor and low price for butter.

(2.) Ease of Churning.—It has been found true, especially in cream raised by the gravity system, that cream churns more readily when ripened. This is probably due to the influence of acid upon casein.

(3.) Increased Yield of Butter.—In ripened cream, churning appears to remove the fat more completely from the cream, especially in the case of gravity-raised cream, and, consequently, the yield of butter is greater.

(4.) Better Keeping Quality of Butter.—It is quite generally believed that the keeping quality of butter is better when made from properly ripened cream than from cream improperly ripened.

(5.) Greater Uniformity in Quality of Butter.—It is undoubtedly true that only by the use of properly ripened cream is it possible to produce butter that is uniform in quality from day to day. This is a matter of the first importance to butter makers, because the same customers want the same kind of butter, when they once get the kind that suits them.

30. Mixing Cream of Different Ages.

It often happens that when the amount of cream produced in a day is small, that the cream each day is set aside and additions of new cream made from day to day, until enough has been accumulated for churning. There results a mixture of cream varying in degrees of ripeness. The different portions vary in the length of time in which they will churn, one portion requiring less churning than another. The result is that churning is stopped before all the fat has been removed from the cream and much fat is lost in the buttermilk. The flavor of butter made from such cream can hardly be as uniform as that made from cream uniformly ripened. If different creams, varying in degree of ripeness, are to be churned together, it is essential that they should be mixed together, at least twelve hours before churning; then the degree of acidity will be uniform throughout the entire mass of cream.

31. Pasteurizing Cream for Butter-Making.

In pasteurizing cream for butter-making, less care is required than when cream is pasteurized for direct consumption. The cooked taste occurring in cream when heated above 156 degrees F. is absent from butter made from such cream, even when cream has been heated at high as 185 degrees F. High heating of cream, however, acts injuriously upon the texture of the butter. In using pasteurized cream for butter-making, the heated cream should be quickly and completely cooled after pasteurization, and the ripened cream should be chilled to 48 degrees F. for about two hours before churning. Treatment in this manner overcomes the tendency of any injury occurring to the grain or texture of the butter.

32. Richness of Cream for Butter-Making.

How rich in fat should cream be made for butter-making? By the gravity method of creaming, we obtain cream containing 15 to 20 per cent. of fat, and by the separator we produce cream of any fat content desired. Good results in every respect may be obtained by the use of cream varying greatly in fat content. The tendency has been to use rather rich cream containing 35 to 40 per cent. of fat, in which case a lower temperature is used in churning, usually with loss of less fat in buttermilk. In order to ripen rich cream in the same length of time as poorer cream, somewhat more starter needs to be used, as the richer cream ripens more slowly than poorer cream under the same conditions.

33. Conditions Affecting Churning.

Churning is the term applied to the process by which the fat-globules of milk or cream are made to unite into visible aggregations, and to separate from the milk-serum or buttermilk. This massing together of fat-golbules is usually produced by the vigorous agitation of cream in vessels especially constructed for the purpose, called churns. When milk or cream is agitated at a temperature somewhat below 85 degrees F., the average melting-point of milk-fat, the fat-globules gradually attach themselves together, each of the small masses first formed continuing to increase in size by uniting with others, until finally the whole of the fat, thus separated, can be collected in one mass. The readiness with which fat-globules separate from cream in churning is influenced by several conditions, among which we may mention, as the most important, (1) the composition and size of the fat-globules, (2) the composition of the milk-serum, (3) the degree of ripeness of the cream, (4) the temperature used in churning, and (5) the kind of agitation or churn.

(1.) Composition and Size of Fat-Globules.—The readiness of fat-globules to separate from milk-serum and unite in visible masses during the process of churning, is influenced by the composition and size of the fat-globules. As pointed out in section 3, p. 13, milk-fat varies in its composition, and this variation in composition affects the hardness or softness of the fat. This quality is influenced by the character of the cow's food. Thus, succulent feeds and feeds rich in starch and sugar make the fat softer. Cottonseed-meal makes the fat harder. Now, it is known that the fat-globules unite more easily in churning when they are composed of softer fat, and less readily when they have larger proportions of hard fat.

In respect to the influence of the size of fat-globules upon ease of churning, the larger the fat-globules the more easily and quickly

they unite. Owing to their size, the larger ones come into contact more quickly and more often than do the smaller ones.

(2.) Composition of Milk-Serum.—The albumin, casein and milk-sugar contained in milk or cream tend to keep the fat-globules from coming together easily. The larger the amounts of these constituents, the less readily will the fat-globules come together. This is one of the reasons why churning is often so slow and difficult in the case of cream from the milk of cows far along in lactation, since at that time milk contains larger proportions of these constituents than earlier in lactation.

(3.) Degree of Ripeness of Cream.—The fat-globules of ripened cream churn more readily and completely than those of sweet cream under like conditions, especially in the case of cream raised by gravity. The lactic acid coagulates the casein and thus greatly decreases the strong influence it has in its usual condition to keep the fat-globules from coming into contact with one another.

(4.) Temperature Used in Churning.—The condition that exercises most influence upon the ease with which the fat-globules unite in churning is the temperature of the cream. This determines, more than any other factor connected with churning, the hardness or softness of the fat-globules. When the temperature is too low, the fat-globules are so hard that they do not stick together when they come into contact, and, consequently, no butter results. When the temperature is too high, the agitation of the fat-globules in churning tends to break them up into smaller globules rather than to unite them into larger masses, thus forming a more complete emulsion, more difficult to churn than the original cream. Fat-globules may be made to unite at temperatures as low as 46 degrees F., and as high as 80 degrees F. Thus, the range of possible churning temperatures is very considerable, but the quality of butter produced at different temperatures is very different, particularly in texture. The butter is in the most satisfactory condition at the end of churning, when the temperature of the cream during churning has been such that the fat-globules have united readily into firm, solid granules of butter, with a minimum content of buttermilk. No particular temperature can be prescribed for churning, as other conditions enter in to modify the temperature of churning, such as (a) the individuality of cows, (b) the stage of the lactation period, (c) the character of the food eaten by the cows, (d) the season of the year, (e) the thickness of the cream, and (f) the degree of its ripeness. The conditions mentioned that are immediately connected with the cow, influence the composition of the milk-fat, making it harder or softer, as stated above. The harder the milk-fat, the higher the temperature at which churning should be done, and the softer the milk-fat, the

lower the proper churning temperature. In the case of cream from the milk of cows far along in lactation, or of cows fed exclusively on dry feed or with considerable cottonseed meal in the ration, the churning temperature usually needs to be higher. In the case of cream from the milk of cows in the earlier stages of lactation, or of cows fed on succulent foods or foods rich in starch or sugar, the churning temperature should be lower. Generally speaking, a lower churning temperature should be used in summer and a higher one in winter. The richer cream is in fat, the lower the temperature that can be used successfully in churning, and the poorer the cream is in fat, the higher should be the temperature of churning, all temperatures, of course, being within the limits required for making butter of good quality. For example, cream containing 15 per cent. of fat may be churned at 58 degrees F. to 62 degrees F.; cream containing 40 per cent. of fat may be churned at 50 degrees F. Lower temperatures remove the fat most completely. Ripened cream can be satisfactorily churned through a greater range of temperature than sweet cream can, especially in the case of cream raised by gravity. From the foregoing statements, it can readily be seen that no fixed temperature can be given as the correct one at which cream in general should be churned.

(5) Kind of Churn.—Different churns are made so as to give each a different kind of motion to the cream in churning. Thus, we have (a) churns with a beating action, (b) swinging, cradle and rocking churns, (c) horizontal churns with dash, (d) vertical churns with dash, and (e) churns with a variety of special contrivances for stirring the cream. On the whole, experience appears to show that the best churns are simple barrel or box churns, entirely hollow, without special paddles or stirring apparatus inside. In such churns, the agitation of the cream is caused by the striking of the particles of cream upon the sides of the revolving churn rather than by a stirring motion. When paddles or other means of stirring are used in churning, it is believed that the texture of the butter is liable to be injured. The speed of churning should be such that the motion of the cream will stop just short of taking on the centrifugal motion of the churn. The object to be kept in view is that the particles of cream shall move about against one another most frequently and thus give the fat-globules the greatest chance to come into contact one with another.

34. When to Stop Churning.

Butter is said to "begin to come," or to "break" when the fat-globules have formed masses sufficiently large to be readily seen in the cream. From this point, the process of churning is soon

completed. In finishing the operation of churning, two points should be aimed at, (1) completeness of churning and (2) retention of smallest practicable amount of buttermilk in butter granules.

(1.) Completeness of Churning.—By completeness of churning we mean the extent to which the fat has been gathered from the milk-serum into butter. This is shown by the amount of fat left in the buttermilk, and is governed by several conditions, which have already been mentioned. Thus, the loss of fat in buttermilk is greater in mixed creams of varying degrees of ripeness than it is in uniformly ripened cream; it is greater at higher temperatures of churning than at lower ones. As an indication of when the fat is removed as completely as practicable by churning, the size of the butter granules may be taken, though not always. The usual instructions given are to stop churning when the butter granules are about the size of kernels of wheat. This cannot always be relied upon as showing that the churning has been completed, since, under differing conditions, the completeness of separation differs with the size of butter granules. The appearance of the buttermilk is usually a good indication of the completeness of churning; when the fat has been most efficiently removed, the buttermilk should look bluish and thin or watery, an appearance not difficult to distinguish. As a rule, churning should be continued until the buttermilk reaches this condition, without reference to the size of the butter granules. When the churning is most effective, the buttermilk should not contain more than one-tenth of one per cent. of fat.

(2.) Amount of Buttermilk left in Butter.—The larger the granules of butter at the close of churning, the greater the amount of buttermilk remaining in the butter. This is an undesirable condition, since the keeping quality of butter is unfavorably affected by the presence of much buttermilk. Every effort should be made so to control the conditions of cream ripening and the conditions of churning that, when the butter granules are the size of wheat grains, the fat will be removed from the buttermilk as completely as is practicable.

35. Difficulties Experienced in Churning.

It is a common experience, especially in making butter at home, to have churnings in which the fat-globules separate in granules with extreme difficulty from the buttermilk, or refuse to separate at all. Various conditions may cause this behavior. Some of these have already been referred to in connection with the conditions of churning. To some of these we will call more detailed attention at this

point, including (1) the influence of advance of lactation, (2) improper ripening of cream, (3) cream poor in fat, and (4) low temperature of churning.

(1.) Influence of Advanced Lactation.—In the case of cows that are far advanced in lactation, we find a combination of conditions that work against the ease of churning, such as small size of fat-globules, milk-fat of harder character than normal, and a larger amount than usual of albumin, casein and milk-sugar in the milk and cream, thus increasing the resistance offered to the uniting of the fat-globules. In the case of cows that come into milk in the spring, these conditions are noticeable in the winter, when, in addition, the food is often largely dry hay or straw. These conditions may also be aggravated by improper ripening of cream. To overcome the difficulties of churning caused by these conditions, the cows must be given succulent feed, such as silage or roots, and the cream must be ripened so as to develop more than the usual amount of acid. In extreme cases, some additional help may come from diluting the cream slightly with warm water or by adding dilute salt brine.

(2.) Improper Ripening of Cream.—The cream should be ripened under the conditions previously given (see sections 26 to 28, pp. 583-586).

(3.) Cream Poor in Fat.—Usually, it is more difficult to churn completely cream poor in fat. This condition needs to occur only when gravity methods are employed in raising cream. By using the centrifugal method of separating cream, no trouble need ever be experienced in this line.

(4.) Low Temperature in Churning.—In churning at very low temperatures, the agitation mixes air with the cream and the cream often froths or swells. Under these conditions, it is best to let the cream stand several hours and then to warm it up slowly four or five degrees, before trying to churn again. Revolving churns give less trouble in this respect than dash churns. Then, again, in churning at low temperatures, the formation of butter may stop just short of the "breaking" point and not be affected by further churning. In such cases, the difficulty may be overcome by adding a little dry salt to the cream or a little water of the temperature of 85 degrees F. to 90 degrees F.

36. Removing Buttermilk from Granules.

When the churning has been completed and the fat has been gathered into granules successfully, the next step is to remove the buttermilk from the butter. As previously stated, the butter at this stage should be in granules not larger than kernels of wheat, and the buttermilk should be clear and watery in appearance, if the cream has been properly ripened and the churning done

at the right temperature. By the old way, the churning was continued until all the butter was gathered into a fairly solid chunk and was then removed from the churn and the buttermilk was removed by pressure at the same time the salt was worked into the butter. The usual method now is to stop the churn when the butter is still in the granular stage, add a little cold water to favor the separation of the smaller fat globules still remaining in the buttermilk. The buttermilk is then drawn off from the bottom of the churn and allowed to drain completely, after which water having a temperature of 45 degrees F. to 55 degrees F. should be added in amounts about equal to two-thirds of the buttermilk removed. The water and butter granules in the churn are then greatly agitated, enabling the water to come into contact with every butter granule, care being taken to avoid an amount of motion that will cause the granules to mass in chunks. In about fifteen minutes, this water should be drawn off, the granules allowed to drain thoroughly, and then the operation of washing should be repeated a second time as before. The second wash water should appear clear as it runs away, or, at most, have only a very slight milkiness. If the churning operation has been properly conducted, two washings should suffice to remove the buttermilk. The less washing that is necessary to remove the buttermilk the better. A small amount of salt added to the first wash water aids in removing the buttermilk without salting the butter appreciably. The texture of the butter and the amount of water in it are affected by the manner in which the washing is done, and by the condition of the butter granules.

(1.) Influence of Washing upon Percentage of Water in Butter.—When the butter granules are small and the wash water very cold, more water remains in the butter without appearing in the form of distinct drops than is the case when the granules are larger and the water less cold. If the end of the churning leaves the butter in chunks of the size of a small plum or larger, it is impossible completely to wash the buttermilk out of the butter, and especially if the butter is soft. In such a case, the buttermilk must be removed by working, but can not be done completely even then, and the butter will have a high water content.

(2.) Influence of Washing on Texture of Butter.—The temperature of the water used in washing butter affects the texture of the butter. When butter is soft at the end of churning, and it is hardened by being rapidly cooled down by the addition of large amounts of very cold water, the texture is likely to show the effect of the rapid change of temperature. When thus treated, the outside of the butter granules cools some time before the inside, and if time is not given for complete cooling before it is worked, we have a part of

the butter still soft. In case the butter granules are soft at the end of churning, as the result of too high temperature in churning, the proper method of procedure is to use the usual amount of water at the usual temperature and allow the butter to remain in it, until it has become thoroughly cooled clear through. If treated in this way, it can be worked without risk of getting soft again at once. In addition, the use of large amounts of water in washing butter is apt to remove some of the compounds that give the butter its flavor, producing a flavorless or tallow-like tasting butter.

37. Working Butter.

The real objects in working butter are (1) to mix the salt with the butter and (2) to get the butter into a solid mass suitable for market. Working butter more than is necessary to accomplish these two purposes is not only useless but may be worse than useless when carried to such an extent as to injure the texture or grain of the butter. There is least danger of injuring the grain of butter, when the working is done by pressure, at a temperature of 45 degrees F. to 55 degrees F. The mistake should be avoided of depending upon working to remove moisture, since this is controlled by the size of the butter granules and the temperature of churning. Fine granules and low temperature favor assimilation of moisture.

38. Salting Butter.

The specific purpose for which salt is added to butter is to give taste. The small amount of salt present in butter has little to do with the keeping properties, as only larger amounts of salt have marked antiseptic effect. The one guide upon which to depend as to how much salt shall be added to butter must be the special market in which the butter is sold, in other words, the taste of the consumer. In actual practice, the amount of salt varies all the way from a trace to two and one-half ounces for each pound of butter. The amount of salt preferred by most consumers is three-fourths of an ounce to one ounce of salt for a pound of butter. In some creameries, butter is made for several different markets, requiring all kinds of salting and extreme pains have to be taken to have each kind always uniform. In order to turn out butter of the same uniform quality from day to day, it is essential that the amount of salt retained in the butter shall be the same, or with the least variation possible. It would seem to be a simple matter to control the amount of salt in butter by weighing the drained butter and salting this in proportion to its weight. But the drained butter is not of constant composition from day to day, because the size

of the butter granules and the amount of water clinging to them are not uniform and, hence, the weight of the washed, drained butter granules does not bear a constant, definite relation to the amount of butter when finished. The larger the amount of water in the butter granules, the larger is the amount that will go out on salting and working, and the less will be the amount of salt left in. When the creaming is done by a separator, and a cream of uniform composition is used from day to day, the weight of cream affords a better basis for calculating the amount of salt to use than does the weight of washed butter granules. The salt can be incorporated easily and evenly into the whole mass of butter, if it is added while the water is being pressed from the butter in the worker. It is important to continue the working until the salt completely dissolves, because undissolved particles of salt may cause mottled or streaked butter. A particle of solid salt remaining in the butter may later dissolve in the water contained in the butter and thus form a strong brine at that point, which tends to deepen the color of the butter that comes in contact with this drop of strong brine. Care should be used in the selection of dairy salt, as different brands of salt vary in their fitness for use in salting butter. Generally speaking, good dairy salt should have a uniform size of particles, should be dry and should completely dissolve to a clear solution.

When a small amount of salt is desired in butter, it can be more uniformly and completely incorporated into the butter by using brine instead of dry salt. For this purpose, a brine is prepared by dissolving in warm water all the salt that can be made to dissolve. This brine is cooled to the proper temperature and poured over the butter. The brine may take the place of the second wash water and allowed to stay with the butter about ten minutes, when it is drawn off and a second portion of saturated brine added to the butter for the same length of time. Then the brine is removed and the working done in the usual manner.

39. Packing Butter for Market.

Butter is in condition to pack for market when the salt entirely in solution has been completely and uniformly worked through the butter, and the water in the butter reduced to the desired amount. When butter is to be kept for some time before marketing, it should contain less water than butter intended for immediate use. Popular taste at present appears to call for a comparatively large amount of water in butter when it is consumed fresh. A large amount of water in butter that is to be kept awhile before consumption is objectionable, because sooner or later the water evaporates from the surface, leaving a coating of salt, and the appearance is injuriously affected.

The problem of a perfect butter package yet remains to be solved; that is, a package which is strong, light in weight and air-tight. Packages made of crockery, glass or metal are heavy and liable to be broken. Tin and iron packages rust easily in the presence of the brine. Wooden packages are seldom air-tight. It appears to be the general impression that wooden packages are in all respects the most available. The materials most commonly used are probably ash, spruce and oak. Wooden packages are subject to the disadvantage of imparting their flavor to butter when it is kept in them long. Therefore, great pains must be taken to remove the odor of wooden packages as far as possible before they are used. This may be done by steaming the packages thoroughly and then filling them with hot water, containing some salt. After standing twenty-four hours they are steamed a second time and then filled with cold water.

For direct consumption, butter may advantageously be packed in moulds or prints. The popular demand for this style of package has increased greatly within a few years and its popularity appears to become greater all the while. Prints in pound and half-pound sizes are found in every grocery. The standard size for pound prints is $4\frac{5}{8}$ by $2\frac{1}{2}$ by $2\frac{3}{8}$ inches, and the shape is rectangular. Each print is wrapped separately in parchment paper and special packing boxes are furnished for carrying them.

40. Qualities of Butter.

Certain points have been adopted by common consent to use as a basis or standard in judging of the value of butter. The qualities that have been selected for this purpose are, (1) flavor, (2) texture, (3) color, (4) salt and (5) general appearance. To these may be added (6) moisture and (7) solidity.

(1.) Flavor.—Butter is said to have a good flavor when it possesses the characteristic taste and odor of good butter in a well-marked degree. It is difficult to describe in words what this flavor is, but it is commonly described as a nutty flavor, clean, aromatic and sweet. It should be entirely free from any rancidity or any other unusual flavor. Personal preference forms a very large factor in judging the value of butter in so far as it depends upon flavor. High flavor, for some persons, means sour milk or buttermilk flavor, while, for others, such a flavor must be absent. The real flavor of high-grade butter can be produced only under most favorable conditions of manufacture. Every operation must be conducted with care, and extreme pains must be observed at all times in respect to cleanliness. The one step in the operation of butter-making that has most influence directly upon the flavor of butter is the ripening of

the cream, and too great care can not be taken to have perfect control of this delicate process. Food also exercises some influence. The flavors that are objectionable in butter may come from food, from the absorption of bad odors by the milk or cream, from the action of undesirable forms of bacteria and from excessive amounts of buttermilk retained in the butter.

(2.) Texture.—The texture of butter refers to what is called the grain and depends upon the condition of the butter granules. In its first formation in churning, butter appears in very small, irregular grains or granules. These grains retain their individuality throughout the rest of the process of butter-making and even in the finished product. The more distinct we can keep the individuality of the granules and at the same time make the butter into solid masses, the better is the texture. The granular texture of butter is seen when a mass of butter is broken into parts transversely, giving somewhat the fractured appearance seen in broken cast iron and free from a greasy appearance. Another method of testing the texture is to pass a knife blade or a butter trier through the butter; when it is withdrawn, no particles of butter stick to it. The texture of butter is injured by allowing the butter granules in the churn to become too large, and by working at too high a temperature or too much. The granular texture of butter is entirely and permanently destroyed by warming butter up near to the melting point.

3. Color.—The standard of color for butter is the color given when the butter is made from the milk of a cow feeding upon fresh pasture grass—an even, bright, golden yellow. Just what substance it is that gives butter its natural color, we do not know yet, but we do know some of the conditions that influence its color, such as the breed of cow, character of food and stage of lactation period. Butter tends to become lighter in color toward the end of a cow's lactation period, and especially if the cow at that time is fed exclusively upon dry foods. On fresh pasture, some cows produce butter somewhat too high in color for the critical consumer. Most butter in commerce is artificially colored. There is quite a number of different butter-color preparations in the market, some of which are aniline compounds and are poisonous when used in considerable quantities. If a butter-color is used, it is wise to use annatto or other preparations, which are known to be harmless. When butter is artifically colored, the colored product should be uniform, of a bright, golden-yellow color, free from any reddish tinge. Different shades of color are called for by different markets.

(4.) Salt.—The main point in connection with salt in butter as affecting quality, is that the salt should be entirely dissolved and

distributed uniformly throughout the entire mass of butter. As to the amount of salt in butter, this must be judged entirely according to the standard of the special trade for which it is made.

(5.) General Appearance.—Under this head we include the attractiveness of the package and packing, cleanliness, etc.

(6.) Moisture.—The water should be so completely incorporated with the butter that it fails to show its presence, not appearing in the form of free beads of water.

(7.) Solidity.—By this is meant the quality of firmness or hardness, not melting or softening too easily.

The different qualities indicated above are used in a specific manner for determining the market value of butter, each quality having assigned to it a definite numerical value. The following so-called scale of points is in common use in the markets of this country:

Flavor, 40 to 45.
Texture, 25 to 30.
Color, 10 to 15.
Salt, 10.
Appearance, 5.

41. Composition of Buttermilk.

Buttermilk is the product, containing water and milk solids that remains when fat is removed from milk or cream in the process of butter-making. In general composition, buttermilk resembles skim-milk, containing, like skim-milk, all the constituents of milk, but in different proportions. The amount of fat in buttermilk is of the greatest importance in connection with churning, for only by knowing the amount of fat in buttermilk can we tell with certainty how complete the churning is. So, the buttermilk should always be tested in order to know whether large amounts of fat are being needlessly wasted by being left in the buttermilk. We have already discussed the conditions that affect the amount of fat left in buttermilk, in sections 33 and 34. If the conditions of butter-making are properly controlled, there need not be left in the buttermilk more than one-tenth of one per cent. of fat. Buttermilk from ripened cream differs from that obtained with sweet cream, the former containing less milk sugar, more lactic acid and less milk-fat. The following analysis will serve as an illustration to give a general idea of the composition of buttermilk obtained under the best conditions:

	Per cent.
Water,	90.60
Fat,	0.10
Casein and albumin,	3.60
Milk sugar,	4.40
Ash,	0.70
Lactic acid,	0.60

CHAPTER VI.

THE RELATION OF MILK TO YIELD OF BUTTER.

If we compare the composition of milk with that of butter, we are impressed with the fact that a very small amount of the solids contained in milk, excepting milk-fat, goes into butter. Below we give an illustration showing, under the conditions stated, the distribution of milk-fat through the various operations of butter-making.

42. Distribution of Milk-Fat in Butter-Making.

In the accompanying illustration we assume that we start with 1,000 pounds of milk, containing 4 per cent. of fat; that we produce, in creaming, 200 pounds of cream and 800 pounds of skim-milk, containing 0.10 per cent. of fat; that in churning we produce 155 pounds of buttermilk, containing 0.20 per cent. of fat, and 45 pounds of butter. We will assume also that the mechanical losses of fat amount to 0.30 pound of fat. The following tabular arrangement brings out the manner in which the milk-fat is distributed through these various operations:

	Per cent. of fat in milk.
1,000 pounds of whole-milk contain 40.0 pounds of fat,	100.00
200 pounds of cream contain 39.2 pounds of fat,	98.00
800 pounds of skim-milk contain 0.8 pounds of fat,	2.00
155 pounds of buttermilk contain 0.3 pounds of fat,	0.75
45 pounds of butter contain 38.6 pounds of fat,	96.50
Mechanical losses of fat in various operations, 0.3 pounds of fat,	0.75

Of the amount of fat contained in the whole milk at the start, 98 per cent. went into the cream and 2 per cent. into the skim-milk, 0.75 per cent. into the buttermilk and the same amount was lost mechanically, while 96.5 per cent. went into butter. The total percentage of loss was 3.5 per cent. of the fat originally in the milk.

43. Relation of Fat in Milk to Yield of Butter.

We have seen that it is not milk-serum that produces butter, but it is milk-fat. Hence, if we wish to know the butter-making value of milk, we must know the amount of fat in milk and then we can tell very closely how much butter should be made from 100 pounds of any particular milk. Now, the question arises: "How much butter should be made for each pound of fat present in milk?" Taking the illustration given in the preceding paragraph, we have 1,000 pounds of milk containing 4 per cent. of fat, or 40 pounds of milk-fat, and from these 40 pounds of milk-fat we obtain 45 pounds of butter; that is, for each pound of fat in milk, we make one and one-eighth pounds of butter, or just one pound and two ounces. In this case, we made allowances for losses of fat in skim-milk, buttermilk and handling, which ought not to be exceeded in practice, when the different operations are carried on with proper skill and care. In general, we may lay this down as a fair rule to follow: Each pound of fat in milk should make one pound and two ounces of finished butter.

The question may next be asked, "Why do we have two ounces more of butter than we do of butter-fat or milk-fat?" While we lose a little fat in the operation of butter-making, we add to the milk-fat considerable water and some salt and retain a little casein, so that we not only make up for the fat lost but really add more than enough water, etc., to make up the loss. In the illustration above given, we had 40 pounds of milk-fat to start with, we lost 1.4 pounds in various ways in making butter, leaving for the butter 38.6 pounds of fat, and to this amount of fat we added 6.4 pounds of water, salt, etc., and thus obtained 45 pounds of finished butter. From the foregoing considerations, it can be seen that we need only to know the per cent. of fat in milk in order to calculate the amount of butter to be made from 100 pounds of the milk. It is necessarly only to multiply the per cent. of fat in milk by one and one-eighth or by one pound and two ounces. Thus, we could readily make up a table like the following, covering any range desired:

Per cent. of Fat in Milk.	Pounds of Butter that Should Be Made from 100 Pounds of Milk.
3,	3.37 pounds, or 3 pounds, 6 ounces.
3.2,	3.63 pounds, or 3 pounds, 10 ounces.
3.5,	3.93 pounds, or 3 pounds, 15 ounces.
3.8,	4.27 pounds, or 3 pounds, 4 ounces.
4.0,	4.50 pounds, or 4 pounds, 8 ounces.
4.5,	5.06 pounds, or 5 pounds, 1 ounce.
5.0,	5.62 pounds, or 5 pounds, 10 ounces.

44. How to Detect Losses by Yields of Butter.

Ordinarily, one can detect losses of fat in skim-milk and butter-milk by testing them for their fat content. In the absence of such tests, one can make use of the above rule to ascertain how effective one's work is in getting milk-fat into butter. For illustration, suppose we make butter from milk containing 4 per cent. of fat, and get 4 pounds and 3 ounces of butter. From the rule given above, we should get not less than 4 pounds and 8 ounces of butter, so that we have experienced a loss of 5 ounces of butter for 100 pounds of milk. We have either lost extra amounts of fat or we have failed to retain the usual amount of moisture in the butter or have experienced losses in both of these directions. An experience of this kind should move one to discern the causes of loss and then remedy them. In case the amount of butter is greater than is called for by the rule, then we have incorporated an extra large amount of water in the butter.

45. Milk-Fat as a Basis of Paying for Milk at Creameries.

Until a dozen years ago, milk was very generally paid for by weight alone at creameries. This method was based upon the belief that it was milk that made butter and that all kinds of milk were of equal value, pound for pound, in making butter. The next step in the direction of progress was to pay according to the amount of cream raised, measuring it by volume. This was a partial recognition that different milks varied in their butter-producing value. The method of paying for cream was extremely faulty, because the basis of payment was for so many spaces or inches of cream raised in a can of certain depth and diameter. This method assumed that all cream raised by the gravity system contained the same amount of fat and was, therefore, of equal value for making butter. Investigation showed that this assumption was wholly without foundation and was extremely misleading. The next plan put into practice was what was known as the "oil test," by which an attempt was made to measure the butter-producing values of different creams

by actually churning small portions of cream. This plan was found to be open to several objections. Finally, the discovery of the Babcock test, in 1890, furnished a simple means of determining fat in milk or cream. From that time on, the method of paying for milk and cream at creameries on the basis of the fat content gradually spread until now it is probably univesal. The relation of fat in milk to yield of butter is so obvious that only persons lacking in average understanding can fail to appreciate the significance of such relation.

46. Calculating Dividends at Creameries on Basis of Milk-Fat.

Several different methods may be employed to determine the amount of each patron's dividend, when payment is made on the basis of the amount of fat in the milk. There are calculators published that save most of the details in making calculations. Here we present one of the simplest methods, showing all the necessary details. It is essentially the same as the old method in use when the weight of milk alone was used as the basis for payment, while, on the milk-fat basis, it is the amount of fat that is used in making calculations. We will illustrate this method as employed (1) in co-operative creameries and (2) in creameries where milk is purchased for a definite price.

(1.) In Co-operative Creameries.—Taking the time covered by any one dividend, whether a week or month, it is necessary to know (a) the amount of milk delivered by each patron during that time; (b) the per cent. of fat in the milk during the same period of time; (c) the total or gross amount of money received for the butter produced during the same period; and (d) the amount of expenses to be deducted from the gross receipts, such as cost of manufacture, selling, carting, etc. Having these data, we need only to apply the following rule, which is given, for convenience, in three steps.

Rule. Step 1. To find the amount of milk-fat furnished by each patron: Multiply together the per cent. of fat in the milk and the amount of milk delivered by each patron expressed in hundreds of pounds, and decimals of a hundred. This gives the total amount of fat in the milk delivered by each patron during the dividend period Example:

Name of Patron.	Pounds of milk delivered during dividend period.	Pounds of milk delivered by each patron, expressed in hundreds and decimals.	Per cent. of fat in milk during dividend period.	Pounds af fat in milk delivered by each patron.
A,	350	3.50×	4.0=	14.00
B,	650	6.50×	3.6=	23.40
C,	835	8.35×	5.2=	43.42
D,	965	9.65×	4.4=	42.46
E,	1,200	12.00×	4.2=	50.40
Total number of pounds of fat delivered by all patrons,	....	....	....	=173.68

Rule. Step 2. To find the net value of one pound of milk-fat:Divide the total net receipts by the total number of pounds of milk-fat delivered by all the patrons during the dividend period. Example:

From the amount of milk delivered by the patrons, as given above, we have made, say, 195 pounds of butter, which realizes 18 cents a pounds, after deducting the cost of making and all other expenses. This will give $35.10 to distribute among the patrons. We now divide $35.10 by 173.68, the total amount of milk-fat delivered by all patrons during the dividend period, and we have 20.2 cents as the net amount of money received from butter for each pound of milk-fat delivered.

Rule. Step 3. To find the amount of dividend due each patron: Multiply together the number representing the pounds of milk-fat furnished by each patron and the net price received for each pound of milk-fat.

In this case, the net price realized for each pound of milk-fat is 20.2 cents, and so we multiply by this the number of pounds of fat delivered by each patron. Example:

Name of Patron.	Pounds of fat in milk delivered.	Net price received for each pound of fat (cents).	Amount of money received by each patron.
A,	14.00×	20.2=	$2 83
B,	23.40×	20.2=	4 73
C,	43.42×	20.2=	8 77
D,	42.46×	20.2=	8 58
E,	50.40×	20.2=	10 18

(2.) In Creameries Where Milk is Purchased.—Under this division come those cases where patrons sell their milk outright for such a price as may be agreed upon. In such cases, a standard may be adopted and milk paid for according to this standard. For example, suppose the proprietor of a creamery agrees to pay at the rate of one dollar a hundred for milk containing 4 per cent. of fat, the price being greater or less than this in proportion as the per cent. of fat is above or below 4 per cent. Paying one dollar for 100 pounds of milk containing 4 per cent. of fat is equivalent to paying 25 cents a pound for milk-fat. Applying this rate to the illustration given above, we have the following:

Name of Patron.	Pounds of fat in milk delivered.	Net price received for each pound of fat (cents).	Amount of money received by each patron.
A,	14.00×	25=	$3 50
B,	23.40×	25=	5 85
C,	43.42×	25=	10 85
D,	42.46×	25=	10 62
E,	50.40×	25=	12 60

CHAPTER VII.

PRELIMINARIES OF CHEESE-MAKING.

As compared with butter-making, the process of cheese-making is much more complicated in its details and difficult to control. It is probably true that our best methods of butter-making are much nearer perfection than are our best methods of cheese-making, but many improvements have taken place in the details of the process of cheese-making during the past twelve or fifteen years. Before the actual operation of cheese-making begins, there are several details which can properly be considered in a separate chapter. We shall, therefore, discuss in this chapter (1) the care of milk by the dairyman for cheese-making, (2) the method of testing milk to detect injurious forms of fermentations, (3) the action of rennet in cheese-making, and (4) the ripening of milk for cheese-making.

47. Care of Milk for Cheese-Making.

In section 13, p. 570, we discussed in considerable detail the precautions to be observed in securing clean milk when the milk is to be sold for direct consumption. All the precautions given there in regard to the conditions of cleanliness to be observed apply with equal force to milk that is to be used for cheese-making. However, in the case of milk intended for cheese-making, after it has been drawn, removed from the stable and strained, we do not need to be so careful in keeping the lactic acid bacteria from growing as we do with milk to be sold for direct consumption. While most of the undesirable forms of fermentation, commonly occurring in milk, may work injury in cheese-making, it is, so far as we now know, very necessary to have more or less lactic acid fermentation in the milk and curd during the cheese-making process, in order to make good cheese, especially in the case of our common type of cheese, the American cheddar. There are two additional points to which special attention will now be called in caring for milk for cheese-making and these are (1) cooling and (2) aerating.

(1.) Cooling Milk.—It is desirable to cool the milk down to the temperature of the surrounding air, or, still better, to 60 degrees F., if it has to be kept long. It is a good plan to assist the cooling by constant stirring. Two objects are thus accomplished. In the first place, in milk thus treated the fat tends to cream less rapidly,

a desirable condition, because in the cheese-making process we want to prevent the separation of the fat from the milk as much as possible. In the second place, the stirring helps any substances with odors to escape from the milk, especially the so-called animal odor and any others that may have been absorbed from the air.

(2.) Aerating Milk.—Stirring milk while cooling is one method of exposing it to the air, that is, aerating the milk. The aerating, as well as the cooling, can be advantageously accomplished by using special forms of apparatus designed for the purpose. The most common form of aerator is a strainer-like tin vessel with holes in the bottom. It is held in position somewhat elevated above the milk can by an iron frame. The milk, as soon as drawn, is strained into this at once and the milk falls in finely-divided drops or streams through the air before going into the can. The Star cooler and aerator allows the milk to flow in a thin film over a corrugated metal surface; the cooling is caused at the same time by having cold water flow through the apparatus. While the more common practice is to cool and aerate only night's milk, it is desirable that morning's milk should be similarly treated. It is also desirable that the two milkings should be kept separate and not taken to the factory in the same can, unless the morning's milk is cooled to the temperature of the night's milk before mixing.

As soon as milk has been cooled and aerated, it should be covered, in order to prevent evaporation from the cream layer. If much evaporation takes place, the layer of cream becomes somewhat tough and does not mix back readily into the milk. This is objectionable for two reasons, (a) the loss of fat is apt to be larger in cheese-making, and (b) it is more difficult to obtain a representative sample for testing. This difficulty usually occurs only with night's milk, but can very easily be obviated.

48. Detection of Injurious Ferments in Milk.

It is extremely important at times to find out whether milk is fit for cheese-making, especially, where troubles have been experienced with fermentations that make it difficult or impossible to produce good cheese. At the Wisconsin Experiment Station a simple method known as the "Wisconsin curd test," has been devised for detecting milks that are undesirable for cheese-making. Specially designed apparatus can be obtained at dairy-supply houses, but is not necessary. The test consists in making a small chunk of cheese-curd from milk in a glass jar. Take pint fruit-jars and perforate the covers with a few small holes. Before using, clean them in boiling water. A sample of each of the milks to be tested is placed in a jar, nearly filling the jar, and the jar is placed in water warmed to

about 95 degrees F. to 100 degrees F. Then ten drops of rennet extract are added to the milk in each jar and the contents are thoroughly mixed. The milk is then left undisturbed until completely curdled, after which it is cut in small pieces with a case knife and stirred in order to expel the whey. Care must be taken to clean the knife each time before cutting the curd in each jar. The whey is poured off at frequent intervals, until the curd mats. The curd is then kept at a temperature of about 98 degrees F. for six or eight hours and then examined. If the milk is good, the curd from it has a solid, firm texture, with only a few small pin-holes, if any. It may have some large, irregular holes caused mechanically by the failure of the particles of curd to unite closely. If gas-forming bacteria are present in the milk, they will produce a curd of spongy texture, very full of holes. Other undesirable fermentations may show their presence by producing a curd of soft, "mushy" texture, while others develop offensive odors. By the use of this test, it is easily possible to detect what patron's milk is the source of trouble, or, in the case of a herd, what individual cow or cows. When unfavorable fermentations are met with in factory experience, this test should be promptly and thoroughly applied, and milk found to be responsible for the trouble should be excluded until its character is improved. Also, milk should not be received for cheese-making when it contains as much as two-tenths of one per cent. of lactic acid. This curd test may also be applied to the examination of market milk that is sold for direct consumption.

49. Source and Properties of Rennet Extract.

We have already (see section 9, p. 564) referred to rennet as containing an enzyme or unorganized ferment, called rennet, which possesses the characteristic property of coagulating or solidifying milk-casein, and, on this account, lies at the basis of our cheese-making. Rennet is used in the form of an extract.

(1.) Source of Rennet Extract.—The usual source of rennet is the fourth stomach of a calf that has not stopped living upon milk. The enzyme is separated from this by special tratment, such as soaking in dilute salt water. For cheese-making purposes, it is much preferable to purchase one of the regular commercial rennet extracts rather than to use a home-prepared article. The best brands of commercial extracts are uniform in strength and free from taints, and this is not commonly true of home-prepared extracts. Rennet extract should be kept in a cool, dark place, if it is to keep its strength for the longest possible time.

(2.) Strength of Rennet in Coagulating Milk.—How powerful the action of rennet is in cogulating milk-casein can be seen in cheese-making ,where we use only one part of rennet extract to five thousand parts of milk, and rennet extract itself is only a dilute form of rennin, the real coagulating substance. One part of absolutely pure rennin can coagulate three million parts of milk. Apparently, rennet extract does not exhaust itself by its own action, but can be used repeatedly. For example, if we could recover from whey and curd the rennet used in coagulating milk, it would coagulate an equal quantity of milk again.

(3.) Chemical Action of Rennet.—When rennet acts upon milk-casein, it changes the composition of the casein, forming a new compound, and this new compound which appears as the coagulated substance is called paracasein. Cheese curd is, then, an impure form of paracasein. This paracasein formed by rennet is quite different from the solid substance formed by milk casein when treated with acids.

(4.) Conditions of Rennet Action.—The conditions of rennet action are quite well understood and we will consider some of them. The rapidity and completeness of coagulation of milk casein by rennet are dependent upon the following conditions:

(a.) Acids Affect Action of Rennet.—Milk must be neutral or acid for action of rennet. If milk is alkaline, rennet will not coagulate it. Increased amounts of acids have a very marked effect in increasing the rapidity and completeness of rennet action in coagulating milk casein. Moreover, very small amounts of acid have a very pronounced influence. For example, a sample of fresh milk that coagulated in 110 seconds was coagulated in 30 seconds when one part of lactic acid was added to 5,000 parts of milk.

(b.) Temperature affects time of coagulation by rennet. The quickness with which rennet coagulates milk increases with increase of temperature. For example, a sample of milk that coagulated at 75 degrees F. in 270 seconds, was coagulated in 65 seconds at 95 degrees F. The character of the coagulated substance also varies with the temperature at which coagulation takes place. Below 60 degrees F. and above 122 degrees F., the curd formed is soft and loose, while at 77 degrees F. to 113 degrees F., the curd is much more firm and solid. The activity or strength of rennet is weakened by heat at 120 degrees F., while heated for sometime above 140 degrees F., rennet becomes permanently weaker or entirely inactive.

(c.) Strength of rennet extract increases rapidity and completeness of rennet action, likewise increased amounts of rennet extract. Dilution of milk by water has the effect of diluting rennet extract and so a given amount of rennet extract acts less rapidly and completely in diluted milk than in the same quantity of milk undiluted.

(d.) Different chemical compounds added to milk affect the action of rennet. For example, many acid salts like free acids, hasten rennet action. Alkaline and alkaline salts prevent it. Rennet coagulation is delayed by common salt, borax, formalin and some other substances used in milk preservatives.

(e.) Heating milk above 150 degrees F. for some time makes it coagulate less quickly with rennet than unheated milk. Milk heated to boiling for some time coagulates either very slowly and incompletely or not at all with rennet. The coagulating power of such milks may be restored by adding small amounts of some acid or by adding calcium chloride.

(f.) Milk from different cows behaves very differently to rennet. For example, in some tests made at the same time and under the same condition with samples of milk obtained from fifteen different cows, the time of coagulation by rennet varied in the individual samples all the way from 50 seconds to 23 minutes. Just why such differences exist no one knows.

50. Methods of Testing Rennet Extracts.

Since different brands of rennet extract vary somewhat in their ability to coagulate milk, it is important to have a means of testing their strength, so that we may know definitely their value. The strength of a rennet extract may be ascertained by finding out how long it takes for a certain amount of extract to coagulate a fixed amount of milk at some definite temperature. The two or three rennet tests in use are based upon this general principle. The two forms in common use are known under the names of (1) the Monrad test and (2) the Marschall test.

(1.) The Monrad Rennet Test.—In this test the amount of milk used is 160 cubic centimeters (about five and one-half ounces fluid measure), and the temperature is 82 degrees to 86 degrees F., and the amount of rennet is one-half of a cubic centimeter, which is diluted to 5 c. c. with water. The apparatus furnished for this test by dairy-supply houses makes these measurements simple. Having the rennet previously diluted, one makes the test as follows: The given amount of milk is heated to 82 degrees to 86 degrees F., 5 c. c. of the dilute rennet solution are added and stirred in quickly with the thermometer. A fixed temperature must be used always; it can be any one point from 82 degrees F. to 86 degrees F., but the point must always be the same one. The time when the rennet is added is noted by the second hand of the watch and then again the time when the milk has coagulated, and then we know how many seconds it has taken for the milk to coagulate. The time when the milk coagulates can be seen more sharply by scattering a few par-

ticles of charcoal on the surface of the milk. The milk is started into motion around the dish by stirring with the thermometer, and the charcoal particles stop the instant the milk curdles. By using a stop watch in carrying out this test, great accuracy and delicacy can be attained. In comparing two rennet extracts by this test, the one that coagulates the milk in the quickest time is the strongest. If possible, the same kind of milk must be used in comparing different extracts. (See Fig. 3.)

(2.) The Marschall Rennet Test.—In this test, the same general plan is followed, but the coagulation takes places in a cup on the sides of which are some graduated lines, while in the bottom of the cup is a glass tube, with very small bore. After the rennet is added to the milk in the cup, this fine glass tube is opened and the milk allowed to trickle away, until the milk coagulates and ceases to run. The marks on the inside of the cup show how much milk has run out and the number of spaces uncovered show the strength of the rennet. The stronger the action of the rennet, the more quickly is the milk coagulated and the less runs out and the fewer spaces are uncovered. There are some objections to this test, which should be noted. A difference in the bore of the glass tube in the bottom of the cup makes a great difference in results, and it is found that the bore differs in different cups. In trying different cups, always compare them on the same sample of milk. While the Marschall test is convenient for ordinary factory work, it is not capable of as great delicacy as is the Monrad test and, therefore, is not so well suited for work requiring extreme precision.

51. Ripening Milk for Cheese-Making.

In ripening milk for cheese-making, the aim is, as in the case of ripening cream, to encourage the fermentation of lactic acid, but in a lesser degree than in cream. Let us first consider how we ripen milk for cheese-making and then how we determine when we have ripened milk enough.

(1.) How to Ripen Milk.—Lactic acid may be formed in milk simply by heating the milk to 82 degrees F. to 86 degrees F., and allowing it to stand awhile. This temperature favors the rapid growth of the lactic acid bacteria already in the milk and the fermentation of the lactic acid takes place quite promptly in ordinary factory milk. There are times, however, when either lactic acid organisms are not abundant or other injurious forms of ferments are so abundant as to repress the growth of the acid-formers, and, under such conditions, it is unwise to wait for the development of the acid bacteria. The method is then to develop lactic acid by adding a starter. A starter prepared as described in section 27, p. 584, may be used, or

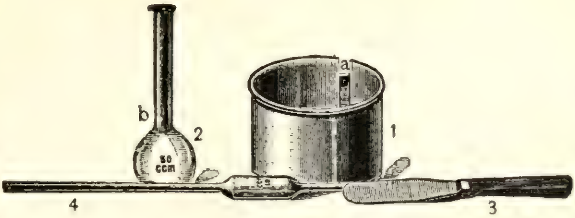


Fig. 3. Monrad's rennet test.

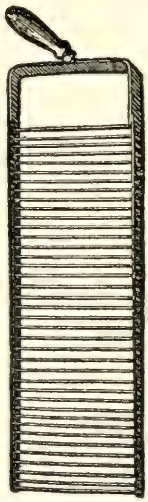


Fig. 4. Horizontal curd-knife.

Fig. 5. Perpendicular curd-knife.

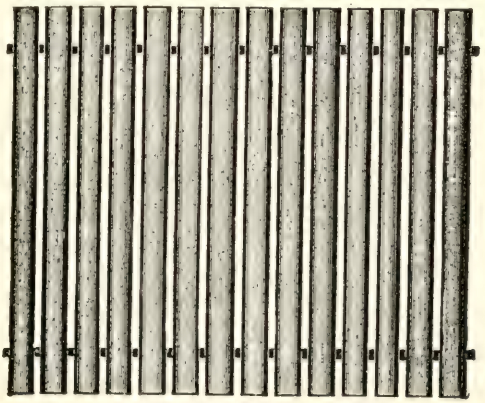


Fig. 6. Curtis improved curd-rack.

Hansen's "Lactic Ferment" can be employed to advantage. The amount of starter to be used in ripening milk for cheese-making should be from two to five pounds of starter for each hundred pounds of milk. The amount will vary according to the temperature of the air and the degree of acidity already in the milk when it comes to the factory. Starters should not be prepared from the mixed milk in the vat or from whey.

(2.) How to Determine the Proper Degree of Ripeness.—Since ripeness in milk means formation of lactic acid, we can measure the ripeness of milk by determining the amount of lactic acid as in the case of cream, but for cheese-making purposes this method is not sufficiently delicate. It has been pointed out above that the activity of rennet is extremely sensitive to the presence of acid; a very minute amount of acid greatly increases the activity of the rennet and reduces the time in which it will coagulate milk. The most satisfactory test for ripeness in milk is to make use of the rennet test in one of the forms described in the preceding section. When milk is found to coagulate by the Monrad test in 45 to 60 seconds, or by the Marschall test in two and one-half spaces, enough acid has developed to enable one to add the rennet for coagulating the milk in the vats. The effect of ripening milk is to hasten the whole operation of cheese-making. The general aim is to have such an amount of acid formed when the rennet is added that the rest of the operation con be completed in six hours. Milk containing as much as two-tenths of one per cent. of lactic acid when brought to the factory is overripe and liable to make trouble in cheese-making. Overripe milk usually causes losses of extra amounts of fat and decreased yield of cheese, since it is difficult for the cheesemaker to control satisfactorily the different operations of cheesemaking.

CHAPTER VIII.

MAKING CHEDDAR CHEESE.

There are two methods in use for making the kind of cheese most commonly found in our American markets, (1) the "stirred curd," or "granular" method, and (2) the cheddar method. The latter is probably more extensively used now. The product is essentially the same, though it is claimed for the cheddar system that the texture of the cheese is more solid, and the product more generally uniform, and with a somewhat smaller content of moisture. We shall describe only the cheddar method.

In the chapter preceding, we have prepared the milk for receiving the rennet. The remainder of the process can be advantageously described under the following divisions:

(1.) Coagulating the milk by rennet.
(2.) Cutting the curd.
(3.) Heating the curd.
(4.) Removing the whey.
(5.) Cheddaring the curd.
(6.) Milling the curd.
(7.) Salting and pressing curd.
(8.) Curing cheese.

The subject of cheese curing is so important that we shall reserve its discussion for another chapter.

52. Coagulating Milk by Rennet Extract.

This is also called among cheese-makers "setting the milk with rennet." It may be stated here, that during the process of ripening, the milk should be more or less constantly stirred, in order to mix back the cream that rises or rather to prevent its rising. The milk is heated gradually to 82 degrees F. to 86 degrees F., and then tested for ripeness. If sufficiently ripe the rennet is added at once; if not ripe enough, it is allowed to stand at the given temperature until it gives the right test. However, if the milk is so lacking in acid as to require too long for the acid to form without help, then use a starter as described above. When the amount of acid in the milk is reached according to the tests given above, the rennet extract should be added. Three points in this connection should be considered, (1) the temperature of the milk when the rennet is added, (2) the amount of rennet extract to be added to the milk, and (3) the method of adding the rennet extract.

(1.) Temperature of Milk when Rennet is Added.—There is a variation of a few degrees in the practice of different cheese-makers. The temperature at which the milk is ripened should be the temperature of the milk when the rennet extract is added, and that point may be anywhere from 82 degrees F. to 86 degrees F. The advantage of the higher temperature is more rapid action and economy of time, especially in ripening, if no starter is used. Milk coagulates more quickly considerably above 82 degrees F. to 86 degrees F., but this range of temperature has been shown by experience to be the most desirable. At higher temperatures the curd hardens too rapidly to allow one to cut it conveniently, and in the subsequent process there is greater liability to loss of fat.

(2.) Amount of Rennet Extract to Use.—The amount of rennet extract to use will depend chiefly on its strength, other things being

equal, and this will have to be determined by the cheese-maker with each new lot of extract, employing the regular rennet test. The guide to keep in mind in determining how much rennet to use is this: Use enough rennet to curdle the milk in fifteen to twenty minutes for a quick-curing cheese, and, in thirty to forty minutes, for a slow-curing cheese. The rennet extracts in common use are added at he rate of two and one-half to five ounces for 1,000 pounds of milk, but generally at the rate of from three to four ounces.

(3.) Method of Adding Rennet Extract.—The rennet extract must be diluted with twenty to forty times its own volume of water, which may be cold or at a temperature of 85 degrees F. to 90 degrees F. The object of dilution is to prevent uneven action of rennet on the milk. If undiluted rennet extract is added to a vat of warm milk, the portions of the milk first coming in contact with the rennet coagulates at once before the rennet has a chance to reach the whole body of milk. The diluted extract acts much less quickly and gives one time to mix it uniformly and thoroughly, through the whole mass of milk. Some makers prefer to dilute the rennet with cold water instead of warm, on the ground that the cold water keeps the rennet inactive longer and thus gives a longer time in which to mix the rennet completely through the mass of milk.

Just previous to adding the rennet extract, the milk should be thoroughly stirred, and then the diluted rennet should be poured into the milk evenly from one end of the vat to the other. The milk is at once gently but thoroughly stirred again so as to mix the rennet completely and uniformly with it, and the gentle stirring is continued for several minutes. Then the surface of the milk is stirred quietly with the bottom of a dipper to keep the fat from separating, this movement being kept up for about half the time required to coagulate the milk but stopping before there is any appearance of coagulation. A cloth is then placed over the top of the vat, if necessary, to keep the surface of the milk from cooling, and the milk is kept undisturbed while the coagulation takes place. The rennet does not act instantaneously so as to show any visible signs, the first indication of acting being a slight thickening of the milk, shown by the slowness of drops of milk to fall from a thermometer or other object dipped in the milk and held up so as to allow the milk to drip from it. The coagulation goes on gradually until the whole mass of milk is one solid, continuous chunk of coagulum or curd, the result of changing milk casein into paracasein. In this process, the fat-golbules and also the other milk constituents are imprisoned in the paracasein.

53. Cutting the Curd.

The object of cutting the curd is to permit the whey to go out of the paracasein. This takes place much more rapidly and completely,

in proportion as the pieces of curd are smaller. The paracasein, or curd, as soon as formed, shows a tendency to contract and this shrinking naturally forces out the whey, the liquid portion of the curd. In cutting, the extent of surface, from which the whey can go out, is enormously increased.

(1.) When to Cut Curd.—It is a point of some importance to know just when to cut the curd, as this has considerable influence upon the rest of the operation and upon the amount of fat lost and, so, upon the yield of cheese. If curd is cut when it is too soft, there will be large losses of fat and decreased yield of cheese. If the curd becomes too hard before cutting, the whey is removed less easily, and the quality of the cheese may be injured. The test used to determine when the curd is in the right condition to cut is the following: The end of the index finger is inserted obliquely into the curd half an inch or more and then slowly raised toward the surface; if the curd breaks apart with a clean fracture, without leaving small bits of curd on the finger, and the whey in the broken surface is clear and not milky, the curd is in the right condition of firmness to be cut.

(2.) How to Cut Curd.—In primitive methods of cheese-making, the curd was broken into small pieces with the fingers or with any kind of instrument, and no attention was given to having the small pieces of uniform size or shape. We now have specially devised knives for cutting curd, which leave the curd in small cubes about three-eighths of an inch in diameter. One curd knife is horizontal (see Fig. 4), with numerous parallel blades; the other is perpendicular (see Fig. 5). Cheese-makers differ in their practice in regard to which knife to use first, but it is a matter of little or no importance. In using the horizontal knife, it is carefully inserted into the curd at one end of the vat, care being taken not to jam the curd in so doing, and is then moved along from end to end until the whole mass has been cut. The perpendicular knife is then used at once, cutting not only from end to end of the vat but crosswise also. The movement of the knife should be somewhat more rapid toward the end of cutting. The object to be kept in mind in cutting is uniformity in size of pieces of curd after being cut. In the case of very ripe or over-ripe milk, the curd should be cut finer. The fineness is governed largely by the number of times the knives are passed through the curd.

54. Heating the Curd.

As soon as the curd is cut, the whey begins to go out of it and the curd settles to the bottom of the vat. If it remains undisturbed, the cut surfaces of the curd easily reunite and, when we break them

apart, additional fat is lost. Therefore, as soon as the curd is cut, the whole mass is kept in gentle motion by careful hand-stirring or with a wire basket made for the purpose. Care must be taken to avoid any rough treatment that would crush or break the curd particles, the object of the agitation being simply to keep the particles of curd moving through the whey and thus preventing their settling and matting. Pains must be taken to keep the curd from settling in the corners of the vat or attaching itself to the sides, since, if left in such places, it will be heated too high later. The whey should appear clear and be fairly free from small particles of floating curd. The curd contracts and hardens during this stirring, but the shrinking takes place more quickly upon the outer surface of the curd particles than upon the inside. This hardening of the out surface prevents the curd particles from sticking together so readily, but offers some opposition to the further rapid escape of whey. In order to favor the continuous expulsion of whey, heat is used at this stage. The term "cooking" is commonly applied to this part of the operation, but the word is misleading, since we use only a gentle heat and in no sense "cook" the curd. The object of heating is to favor the contraction of the curd and the escape of whey. The cause of the shrinking of curd is probably due to union of lactic acid with the paracasein, forming a new compound which has the property of contracting. The heat favors the formation of this new substance, and the more rapidly it forms the more readily the curd shrinks and forces out the whey. Heat is applied gradually and the stirring is kept up constantly. Under normal conditions ,the heat is applied so as to raise the tempertaure of the curd and whey about one degree in five minutes, and rarely more than two degrees in five minutes. The heating should be somewhat slower up to 90 degrees F. than above that point, since the shrinking of curd takes place less rapidly below than above 90 degrees F. The contents of the vat should be heated finally to 98 degrees F. As the the temperature is increased, the curd particles become less tender, and toward the end of the heating they can be stirred much more vigorously without risk of injury. When the temperature of 98 degrees F. has been reached, the curd is allowed to settle to the bottom of the vat and remain quiet with only an occasional stirring, until a certain amount of acid has been formed or rather until a certain amount of the compound of lactic acid and paracasein has been formed.

55. Removing the Whey from the Curd.

The whey should be removed from the curd when a certain amount of lactic acid has combined with the curd (paracasein) or, as the cheese-maker commonly says, when there is "enough acid on the

curd." How can we ascertain this? The behavior of the curd will give us this needed information. In the first place, the curd particles should be contracted to less than one-half their original size, and, in the second place, they should be so firm and rubber-like that when a mass of curd is pressed together between the hands and then suddenly freed from pressure, they should fall apart at once, and show no tendency to stick together. During the heating, the particles of curd should be examined occasionally to ascertain whether they are changing on the inside as well as outside. The third sign given by the curd is probably the most useful to go by in deciding when the curd has been heated long enough and when the whey should be removed, and that is what is known as the "hot-iron test." When a small mass of curd, which has been squeezed in the hand to remove whey, is pressed against a bar of iron, heated a little short of redness, and then carefully drawn away, fine, silky threads are formed, adhering to the iron. These strings are caused by the compound of lactic acid and paracasein and the more of this compound there is, the more the curd will string in length. So the hot-iron test is really a measure of the amount of acid that has been formed. Now, when the curd shows, by the hot-iron test, strings one-eighth of an inch long, the whey is drawn from the curd. The removal of the whey is sometimes called "dipping," or "drawing," the whey. When the development of lactic acid has been rapid or promises to be, it may be well, when the curd has reached 98 degrees F., to let it settle and draw off part of the whey; leaving enough to cover the curd two or three inches deep. Then the rest of the curd can be removed when the curd strings one-eighth of an inch. Too much acid at this point must be guarded against, and the whey must be promptly removed when the right point is reached.

56. Cheddaring the Curd.

This operation is the distinguishing feature of the cheddar method. It consists essentially in allowing the curd to mat or pack together in solid chunks after the removal of the whey. The matting process may take place in the vat directly on the bottom or on curd-racks placed in the bottom of the vat or it may be removed to a special apparatus called a curd-sink.

(1.) Matting Curd on Vat-Bottom.—When the bottom of the vat is used, the curd, after the removal of whey, is piled up along the two sides of the vat with an open channel between the two piles of curd to facilitate the running off of the whey that drains from the curd. When the particles of curd have matted together, forming one solid mass, it is cut into chunks or blocks about 8 by 8 by 12 inches; these blocks are then turned over so that the part at first

uppermost comes against the bottom of the vat. Some whey drains out and then the blocks are piled two deep, care being taken to turn in the parts that have been exposed to the air. Later, the curd is re-piled in still deeper piles. This re-piling continues again and again, always observing the precaution to expose to the air the portions that were turned inside on the previous piling. The object of this is to keep the heat uniform through the mass.

(2.) Matting Curd on Curd-Rack in Vat.—In this case racks are used, made of wooden slats, just fitting nicely into the bottom of the vat (see Fig. 6). They are preferably made in four-feet sections. For their use, the vat is tipped and the curd shoved to the lower end. One section of rack is then placed in the empty end of the vat and a linen strainer thrown over it, the strainer being long enough and wide enough to come up over the sides of the vat. Then the curd is piled onto the rack, and broken apart to let the whey escape. After stirring over several times, it is allowed to mat evenly about six inches deep. If needed, the second section can be put in place and used for the rest of the curd, and then the whole is covered with the strainer cloth to keep warm and, if necessary, the whole vat covered with an additional heavy cloth. After ten or fifteen minutes, the curd is matted together, when it is cut into blocks and treated as described above.

(3.) Matting Curd in Curd-Sink.—After most of the whey is removed, the curd and remaining whey are dipped into the curd-sink and allowed to drain. Then proceed to mat, cut, pile and re-pile as stated above. All things considered, the use of a curd-sink is advantageous.

Piling curd has a tendency to make a quick-curing, soft cheese. If a slow-curing cheese is desired, the curd should be piled only a little or none at all, the blocks being simply turned over and over in a single layer. A curd from very ripe milk should not be piled much.

Cheddaring, or matting curd, accomplishes two results. First, the whey is expelled to a considerable extent and, second, the lactic acid unites with more of the curd, thus changing not only the chemical composition but the physical condition of the curd. From a spongy, tough, rubber-like consistency, with a high water content, the curd changes to a mass having a smooth, velvety appearance and feeling, and a softer, somewhat plastic, consistency. The texture also changes so that the curd acquires a peculiar fibrous condition or grain, tearing off somewhat like the cooked meat of a chicken's breast. Then, in addition, owing also to the increase of the compound formed by the curd with lactic acid, the curd forms longer strings on a hot iron, probably an inch or more after the

cheddaring has continued some time. Usually, when the curd strings one inch and the other physical appearances of the curd are as described above, the curd is ready for milling.

57. Milling the Curd.

Milling the curd consists simply in cutting it into small pieces in order to salt it and handle it conveniently in putting it into hoops for pressing into a solid mass. Several mills are on the market for this purpose. The best machines cut the curd into pieces of uniform size, without tearing it in pieces. When properly milled, there is less loss of fat and the curd is more evenly salted. After milling, the curd is piled up to flatten out the pin-holes and then stirred enough to keep it from matting together, perhaps every fifteen minutes. The time for milling should come about half way between removing the whey and salting the curd. The breaking down or softening of the curd continues after milling, as a result of further formation of lactic acid and its combination with the paracasein of the curd. When the curd forms strings on a hot iron about two inches long, it should be salted. During all this time the curd should be kept warm.

58. Salting and Pressing Curd.

(1.) Salting.—Salt is added to curd chiefly for the flavor it imparts, but the presence of the salt produces several other effects. It aids in removing whey; it hardens the curd; it checks or retards the formation of lactic acid. In the absence of salt a cheese cures more rapidly and is apt to develop a bitter flavor even at moderately low temperatures. Excessive salting makes a cheese mealy because too dry and the cheese cures very slowly.

A salt of fairly coarse grain is preferable for cheese, because it dissolves more slowly and reaches farther into the pieces of curd. When the salt is added, the curd is spread out thin in order to cool to 90 degrees F., and the salt is mixed uniformly through the curd. Then the curd is stirred until the salt is completely dissolved. In respect to the amount of salt to use, the usual amount is two and one-half ounces to three pounds of salt for the curd made from 1,000 pounds of milk. A moist curd should be salted somewhat more.

(2.) Pressing.—Before pressing, the curd should be cooled to a temperature between 78 degrees F. and 84 degrees F. If put in press warmer than this, the fat runs out and is lost and it also prevents the pieces of curd sticking together perfectly. If curd is put in press much below 80 degrees F., the pieces do not cement com-

pletely and so fail to form a solid mass. The main object of pressing is to give the cheese a definite form for market and not to squeeze out whey, though this is done to some extent. The whey should be removed from the curd while it is in the vat. No amount of pressure can make up for failure to remove the whey at the proper time. If the process has been properly carried on so as to form a proper amount of the compound of lactic acid and paracasein, and if the temperature of the curd, when put in the press, is not much below 80 degrees F., a comparatively light pressure will be sufficient to cause the pieces of curd to cement together in a smooth, uniform and solid mass. The pressure should be uniform and continuous for twenty-four hours. When a screw press is used, the pressure must be applied gradually at first and care must be taken, especially during the first hour of pressing, to tighten the screws as quickly as they become loose.

When the cheese has been in press about one hour, it is taken out, turned, the bandage straightened and the entire surface of the cheese wiped with a cloth wrung out of hot water. Seamless bandage is used, being cut long enough to extend over the edges on both ends of the cheese one and one-half to two inches. When the cheese is put back in press, circular cloth caps are put on between the ends of the cheese and the follower and are allowed to remain.

59. Some Common Troubles of Cheese-Making.

The conditions of temperature present during the cheese-making process are extremely favorable to the growth of many kinds of bacteria and, when certain kinds are present, we have undesirable forms of fermentation, producing abnormal behavior in the curd and defective cheese.

(1.) Gas-Forming Fermentations.—One of the common troubles in cheese-making is a "floating," or "gassy" curd. This fermentation produces gas in the curd and bubbles of gas cause the curd to swell, filling it with small holes, so that it becomes very spongy. When the gas is sufficiently abundant, it makes the curd light enough to float on the surface of the whey. The small gas holes can easily be seen inside the pieces of curd by cutting across them. They are usually known as "pin holes," forming a "pin-holey" curd. The source of this fermentation is commonly lack of cleanliness on the part of one or more patrons, and the different milks should be tested by the curd test (see section 48, p. 606), in order to detect the offending party. However, if one is suspicious of the presence of such fermentations in the milk, they can usually be prevented or lessened by abundant use of a starter, developing abundance of lactic acid in the curd. It has been found that these gas-forming

bacteria do not usually develop in the presence of vigorous lactic acid fermentation. The milk is well ripened before adding rennet and the temperature used in heating the curd is raised somewhat more rapidly and two to six degrees higher than usual. The curd is kept warm after removing whey and the escape of gas is favored by frequent turning and re-piling of the curd, thus closing the pin holes. The gas-forming fermentations often produce offensive-smelling gases. When these are present in curd, they may be washed out by drenching the curd with hot water. When a floating or spongy curd is not properly treated, the resulting cheese is defective in texture and flavor, and even when these defects are prevented, there is extra loss of fat and of cheese yield. Prevention by cleanliness is the best method of treatment.

(2.) Over-ripe Milk.—In some cases, especially in hot weather, the milk may have developed too much lactic acid and be on the verge of souring when brought to the factory. When there is so much lactic acid at the start, the changes in the curd take place much more rapidly than usual, or, as the cheese-maker says, the curd "works fast." Under these conditions, the whey does not escape from the curd rapidly enough, that is, the curd has not shrunken enough when it comes time to remove the whey. Under these conditions, the curd is constantly and thoroughly stirred after the whey is removed and the whey is thus well worked out before the cheddaring begins. When it is known at the beginning that the milk is over-ripe, the milk should not be heated to the usual temperature before adding rennet, and a larger amount of rennet is used. After cutting, the curd is stirred until the whey is well separated before applying additional heat.

60. Sizes of Cheese.

The sizes in which cheeses are made depend upon the special market in which one's product is sold. The most common size is 15 inches in diameter and weighs from 60 to 65 pounds. Cheeses of the same diameter and one-half the weight are known as "flats." Other sizes are 13 and 11 inches in diameter. Cheeses 7 inches in diameter are known as Young Americas, usually weighing 8 to 10 pounds.

CHAPTER IX.

CURING CHEESE—QUALITIES OF CHEESE.

The importance of care in managing cheese after it is made has been seriously overlooked. Until quite recently, little attention has been given to methods of cheese-curing in this country. The rule has been and still is, in too many cases, to place the cheese in some room in the factory that is provided with no means of controlling temperature and moisture, where the variations in these factors follow the conditions existing out of doors. It is now being realized that the best-made cheese may be absolutely ruined for market by lack of care during the curing process. The curing of cheese is a part of the manufacturing process and must not be slighted any more than any other important step.

61. Changes Caused by Curing Cheese.

It is well known that cheese must have age before it is salable for consumption. What takes place in cheese while it is acquiring age, that is, while it is curing or ripening? Several different changes occur, which we will briefly notice.

(1.) Loss of Moisture.—It is well known among cheese-makers that cheese begins to lose weight immediately from the time it is taken from press and placed upon the shelves of the curing room, and this loss continues for a long time. The rapidity and extent of loss of moisture in cheese during the process of curing vary with several conditions, such as (a) the percentage of moisture originally present in the cheese, (b) the texture of the cheese, (c) the size and shape of the cheese, (d) the temperature of the curing room, and (e) the proportion of water vapor present in the air of the curing room. The more moist a cheese is when first made, the more rapidly it loses moisture. Cheese with spongy texture loses moisture more rapidly than does cheese with perfect texture. Large cheeses lose moisture less rapidly in proportion to their weight than smaller cheeses. "Flats" lose weight more rapidly than cheeses of the same diameter and twice the height. The higher the temperature of the curing room the greater the loss of moisture. The greater the moisture in the air of the curing room the smaller is the loss of weight.

(2.) Changes in the Paracasein.—In freshly coagulated cheese-curd, the milk-casein has been changed to paracasein, and, with the formation of lactic acid in cheese, the paracasein unites with the acid forming a new compound. Fresh cheese has always been supposed to consist entirely of paracasein, except for the fat, moisture and salt. It has recently been discovered in the laboratory of the New York (Geneva) Agricultural Experiment Station that fresh or green cheese instead of containing paracasein, contains the lactic acid compound of paracasein. Now this compound undergoes changes in the course of ripening, which greatly change the whole character of the cheese. Green cheese is tough, somewhat rubber-like, not appreciably soluble on the tongue, difficult of digestion, and lacking flavor. In the course of ripening, the cheese becomes more or less soft, more easily digestible and acquires characteristic flavors. A piece of well-cured cheese, when placed on the tongue, should dissolve somewhat like a piece of cold butter, leaving no trace of harsh or gritty-feeling particles. Just how the flavor is produced or where it comes from we do not know with certainty. In normal cheese-ripening, the fat undergoes little or no change. The curing process in cheese involves the change from unmarketable to marketable conditions. The exact causes of these changes are not clearly known yet; it is probable that they are due to the combined action of galactase, the enzyme in milk, to the pepsin enzyme in rennet, and to certain forms of bacteria.

62. Temperature for Curing Cheese.

It has been found that cheese cures more quickly at higher temperatures and that, above certain temperatures, the texture and flavor are unfavorably affected. It was formerly thought that a temperature of 70 degrees F. was about right for best results. But it is now known that a temperature of 55 degrees F. or 60 degrees F. gives very much better results, and it is thought that a temperature as low as 40 degrees F. may be still better. Cheese cured at 75 degrees F. or above will suffer more or less from leakage of fat. It may be said with positiveness that cheddar cheese cured above 60 degrees F. does not give cheese of the best quality, either in respect to general character or in respect to keeping qualities. Cheese cures more slowly at lower temperatures, but the product is superior in quality. In addition, at low temperatures, less moisture is lost and one has more pounds of cheese to sell.

63. Moisture in Air for Curing Cheese.

The relative amount of moisture in air can be shown by an instrument (see Fig. 7), called a hygrometer, or hygroscope, which can be

purchased at dairy supply houses. The relative amount of moisture for a curing room for cheddar cheese is from 65 to 75 per cent; the nearer the latter figure the better.

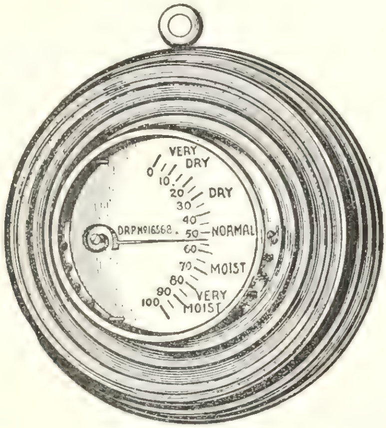


Fig. 7. Hygrometer.

64. How to Control Moisture and Temperature in Curing Rooms.

Ordinarily, each factory must provide for itself a suitable kind of curing room, if it cures its cheese properly. Of course, cheese may be sold and removed from the factory before it is a week old and the whole process of curing placed in the hands of the buyer, who will gain the benefit of the increased value of the well-ripened cheese. This, however, is better than keeping cheese at the factory and spoiling it. In some cases several factories may unite to build a central curing-house, to which the cheese, while still green, can be removed from the factory. But, in many cases, the factory is the place where the curing-room will have to be built if anywhere.

The following statements are, for the most part, condensed from Prof. F. H. King's Wisconsin Bulletin No. 70. The cuts are from the same source.

Curing-rooms may be constructed above ground or under ground and may be of wood or masonry, or a combination. Considering moderate cost, convenience and efficiency, a curing-room built of wood entirely above ground is the most practicable for the average factory.

(1.) Location.—A curing-room above ground should be placed on the north side of a building in order to be protected as much as possible from the direct rays of the sun. It is advantageous also if the room can be shut off on the other three sides by hallways, stairways other rooms or building screens.

(2.) Windows in a curing-room should be as few and as small as consistent with the amount of light necessary. They should be made double, as nearly air-tight as possible, and preferably in one section, fitted closely and permanently in place. If necessary to exclude direct sunshine, blinds or awnings should be placed outside.

(3.) The door of a curing-room should be built to resemble that of a refrigerator.

(4.) Walls should be built like those of cold-storage and ice-houses The studding outside should be covered with matched sheathing and drop siding, with a layer of three-ply acid and water-proof paper between. The paper recommended by Prof. King is manufactured

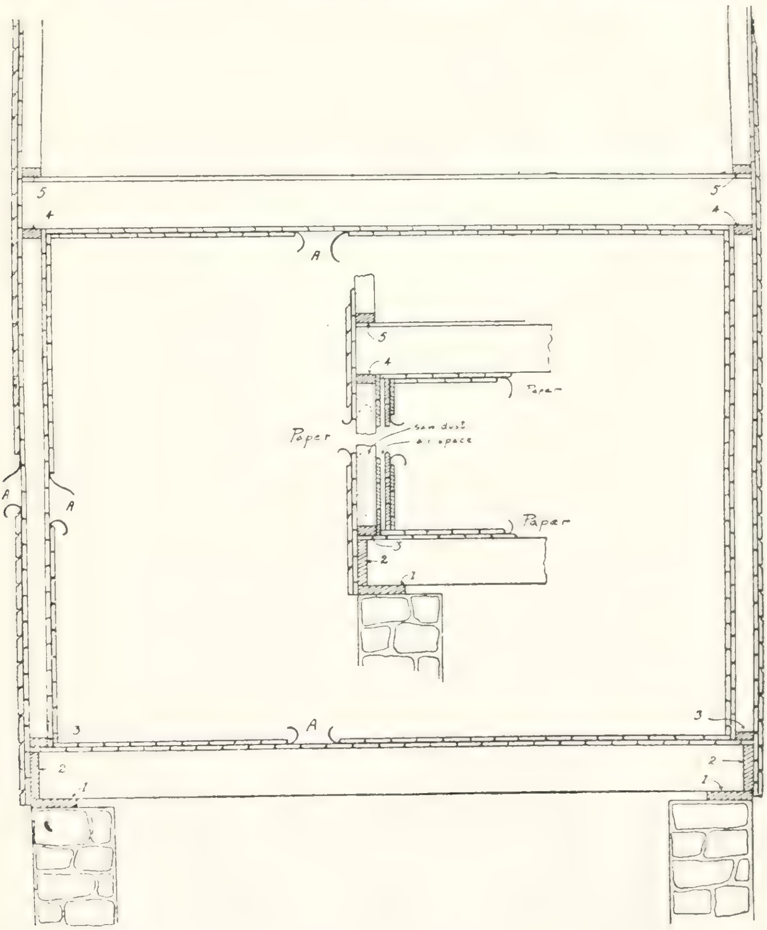


Fig. A. Showing the construction of wood curing-room. 1, 1, 1, sill; 2, 2, 2, a two-by-ten spiked to ends of joist; 3, 3, 3, a two-by-four spiked down, after first layer of floor is laid, to toe-nail studs to; 4, 4, 4, a two-by-four spiked to upper ends of studding of first story. A, A, A, A, three-ply acid and water-proof paper. The drawing in the center shows space between studding filled with saw dust and another dead-air space to be used when the best ducts cannot be provided.

(From Wis. Agr. Exp. Sta. Bul. 70.)

by the Standard Paint Company, New York and Chicago. In the inside a layer of matched sheathing is nailed to the studding, then strips of inch furring two inches wide, to which are nailed two thicknesses of matched sheathing, with paper between. The outer air space between the studding is filled with sawdust or similar material and the spaces left by the furring are closed air-tight at the ceiling and floor. (See Fig. A.)

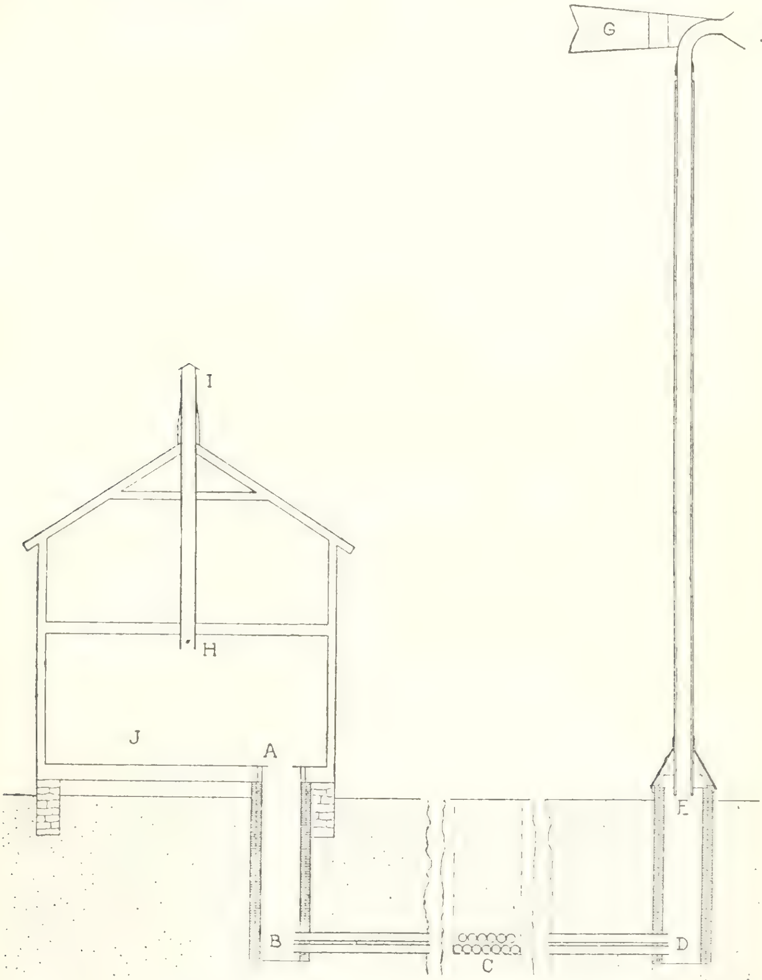


Fig. B. Section of cheese-curing room and horizontal multiple sub-earth duct. A, inlet to curing room; B, end of sub-earth duct in bricked entrance to factory; C, cross-section of the multiple ducts; D, E, bricked entrance under funnel at outer end of sub-earth duct; funnel with mouth 36 inches across; G, vane to hold funnel to the wind; H, ventilating flue with damper.

(From Wis. Agr. Exp. Sta. Bul. 70.)

(5.) Ceiling and floor should also consist of two thicknesses of matched lumber with paper between, and joints made at corners should be very tight.

In constructing curing-rooms two things should be kept in mind; first, that the walls should be as nearly air-tight as possible in order to keep out the warmer air outside and, second, that the walls should be poor conductors of heat. It is advantageous to cover the inside walls with two coats of shellac.

(6.) Ventilating flue in ceiling.—It is desirable to provide a tight ventilating flue in the ceiling of the curing-room, extending above the roof. Its diameter may be six to eight inches. It should be provided with a damper. (See Fig. B, H, I.)

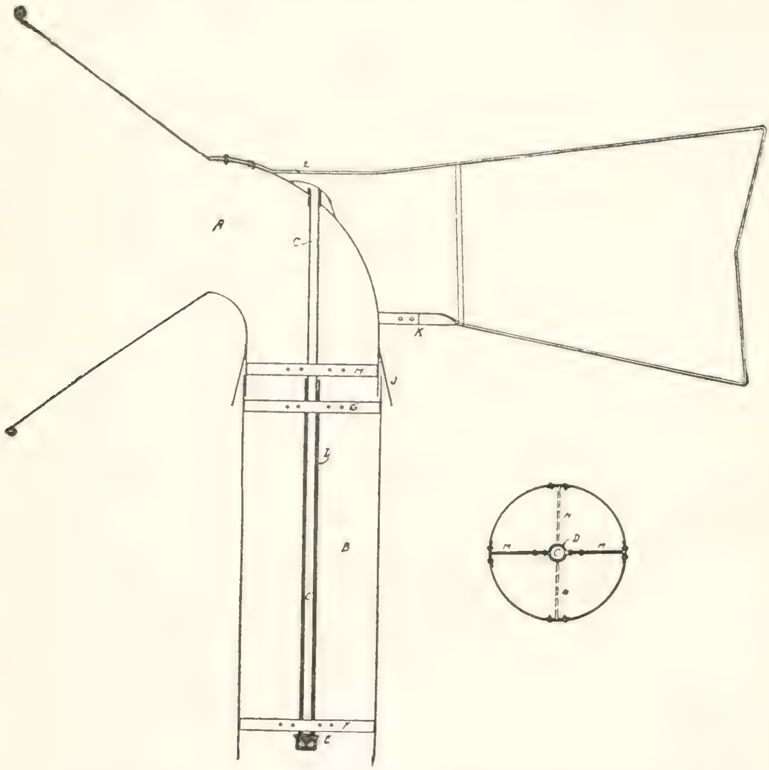


Fig. C. Showing how the funnel and vane may be mounted. A, funnel; B, shaft of funnel; C, C, C, 1-inch gas pipe; D, D, 1¼-inch gas pipe; E, cap for support of 1-inch gas pipe; F, G, H, and M M and N N are stays of band iron bolted together and to the sides of the shaft to support the axis of the funnel; J, weather collar to turn rain out of shaft. K, L, band-iron to stiffen vane and attach it to funnel.

(From Wis. Agr. Exp. Sta. Bul. 70.)

(7.) Methods of Controlling Temperature and Moisture in Cheese-Curing Rooms Placed Above Ground.—After constructing a proper curing-room, it is essential to provide arrangements for controlling temperature and moisture. The construction of a curing-room is only a partial means toward this end. The following methods have been found effective in keeping the temeprature during summer between 58 degrees and 70 degrees F. and at the same time modifying

the moisture content of the air favorably: (a) Ventilation by air forced through horizontal sub-earth ducts or deep vertical sub-earth ducts and wells. (b) Ventilating over ice. (c) Evaporation of water.

Fig. B illustrates the construction of a horizontal sub-earth duct, which should be twelve feet or more below the surface of the ground and 100 feet or more in length. It is recommended that the sub-earth duct of three rows of 10-inch drain tile laid side by

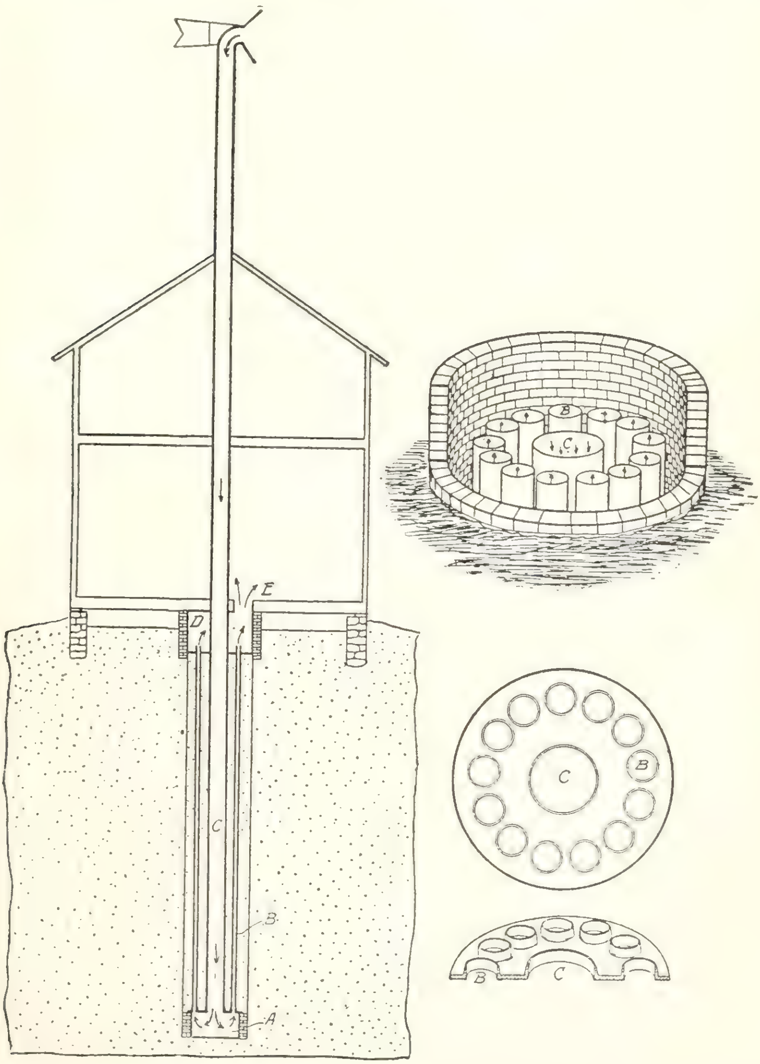


Fig. D. Showing vertical sub-earth duct. A, brick chamber 25 to 30 feet below surface and 40 inches inside diameter; tile or conductor pipe of galvanized iron; C, main shaft of funnel; D, brick chamber at upper end of duct. The circle and section represent a cast-iron plate to cover brick chamber A, and can be had of King & Walker, Madison, Wis.

(From Wis. Agr. Exp. Sta. Bul. 70.)

side at the bottom of the trench, or the trench may be dug narrower and one or two feet deeper and the tile placed one above the other. The shaft for carrying the funnel must be made tight; it may be twelve inches square, if made of plank, or twelve inches in diameter, if made of galvanized iron. The height should be sufficient to enable the funnel to catch the wind readily. The construction and mounting cf the funnel are illustrated in Fig. C. The extreme diameter of the funnel should be about thirty-six inches.

The inlet from the sub-earth duct into the curing-room must be provided with some arrangement of valves that will permit the air to be shut off wholly or partly. Too rapid entrance of air in warm weather will not permit enough cooling during passage through the duct. In case of dry winds, too rapid entrance would reduce the moisture too much.

In Fig. D there is illustrated a deep vertical sub-earth duct. Such a duct has the advantage of requiring less piping and also less wind will suffice to produce a current of air. The vertical duct should have a depth of not less than twenty-five or thirty feet, provided water is far enough from the surface. Thirteen lines of 6-inch drain or 5-inch galvanized iron conductor pipe may be used and placed as in the cut. The duct should be located near the north end of the curing-room or directly beneath it. A hanging platform can be used in placing the pipes or tubes in position and the earth packed carefully around the pipes. An excavation of proper size, made as for an ordinary well, will answer the purpose. After the duct has been placed in position, the earth that has been removed can be used for filling around the duct.

In Canada, considerable work has been done in using ice in curing rooms to control temperature. Where ice can be obtained conveniently and cheaply, this method may be advantageously utilized. One or more ice boxes are placed in the curing-room, so built that air can circulate about the ice and into the curing-room. Also compartments, filled with ice, may be made adjoining the curing-room on the side or above, provided with openings into the curing room which will allow a flow of air over the ice and into the curing-room.

Where special means are needed to secure moisture, this can be effectively done by means of yard-wide strips of any cloth material that has good capillary power. The pieces of cloth are hung about the room and kept more or less saturated with water. Experience will tell how much evaporating surface is needed to provide the degree of moisture needed.

65. Qualities of Cheese.

Certain qualities of American cheddar cheese have been adopted as a basis in judging of the commercial value of one cheese or com

pared with another. The terms used in expressing these qualities are the following: (1) flavor, (2) body, (3) texture, (4) color and (5) general appearance.

(1.) Flavor.—By flavor, as applied to cheese, we mean the odor of the cheese, or really odor and taste combined. The sense of smell is, as a rule, more sensitive in detecting variations of flavor in cheese than the sense of taste. Flavor in cheese is said to be perfect when it resembles that of first-class butter, with an added something of its own that can not be described. The proper cheese flavor should be marked but not strong. The flavor should be free from all other flavors, referring particularly to the more or less offensive products of undesirable fermentations. The taste should be mild and somewhat lasting, but not be so sharp as to "bite" the tongue.

Tainted flavors are numerous in kind and name. They may resemble the odor of the cow or the stable; others are characterized as "sweet and sickish;" others suggest the odor of rotten eggs, and others putrefactive smells. There is the "off" flavor of rancid butter, produced by too long keeping under improper conditions. This list is far from exhaustive.

(2.) Body.—This term, as used in reference to cheese is not easy to define; it means about the same as substance. A cheese is said to have a perfect body when it is solid, firm and smooth in substance. This quality is ascertained by pressing cheese between the fingers. The body is said to be solid and firm, when it shows a certain amount of resistance under pressure, somewhat like that of a piece of fat pork. When it does not press down readily and is tough, the body is said to be "corky." The body is said to be smooth when, under pressure between the thumb and fingers, it feels smooth and velvet-like, as opposed to harsh or gritty or mealy. The firmness of body may be diminished by excessive moisture or by large amounts of fat relative to paracasein compounds, while the smoothness may be increased. The harsh or gritty feeling in cheese may be produced by removal of fat from milk, by excessive acidity in milk, by too much salt, or by any condition that retards or prevents the normal ripening of the cheese.

(3.) Texture.—Texture, as applied to cheese, refers mainly to compactness. Usually the body is considered as a part of texture, but the two qualities are usually quite distinct. The texture may be fine and close or porous. The texture is perfect when a cut surface of the inside of the cheese presents to the eye a solid, compact, continuous appearance, free from breaks, holes and chunks. A porous texture of any kind is imperfect. When a plug is drawn from the cheese, it should be smooth and not "fuzzy." When the

plug is broken in two, it should not crumble, but show a flaky appearance, termed a "flinty break," resembling the surface of broken cast-iron or broken flint. Cheese should show no visible or separated moisture and no fat, separate from the main body of the cheese.

(4.) Color.—Cheese, whether artificially colored or not, should be uniform in color and free from any mottled appearance. When held between the eye and the light, it should be slightly translucent.

(5.) General Appearance.—The rind of cheese should be smooth, free from cracks, and fairly hard. The bandage should be smooth and neatly and uniformly rounded over the edges about two inches on each end of the cheese. The sides of the cheese should be straight and of uniform height all around. The following scale of points is in use in judging cheese according to these qualities:

Flavor, 45 to 50.
Texture, 30 to 35.
Color, 10 to 15.
General appearance, 5 to 15.

CHAPTER X.

THE RELATION OF MILK TO CHEESE.

For a long time, attention was so completely absorbed by methods of cheese-making that very little was accurately known up to ten years ago about the general principles underlying the methods employed. Less than a dozen years ago we were completely in the dark in regard to such fundamental facts as the relation of fat and casein in milk to yield and quality of cheese, the character and extent of losses of milk constituents in cheese-making, their causes and remedies, the influence of removing fat from milk upon the composition of cheese, and in general, the detailed relations existing between cheese and the material from which it is made.

66. Relation of Composition of Milk to Yield of Cheese.

Not many years ago there was a widely prevalent, if not universal, belief that all kinds of milk were practically of equal value for the purpose of making cheese. This belief was based upon two assumptions, (1) that it is impossible to retain the fat of milk in cheese when the milk-fat exceeds 3½ or 4 per cent., and (2) that the amount of casein is practically the same in all kinds of milk. What are the actual facts?

(1.) Proportion of Milk-Fat Lost in Cheese-Making in Different Milks.—Careful and extensive investigations have shown clearly that the amount of fat lost in the process of cheese-making varies comparatively little whether the milk contains more or less fat. The following tabulated summary represents averages obtained with a very large number of experiments carried on by the writer with normal milk varying in fat content from 3 to over 5 per cent.:

	Pounds of fat in 100 pounds of milk.	Pounds of fat lost in whey for 100 pounds of fat in milk.	Per cent. of fat in milk lost in whey.
One,	3 to 3.5	0.32	9.55
Two,	3.5 to 4	0.33	8.33
Three,	4 to 4.5	0.32	7.70
Four,	4.5 to 5	0.28	5.90
Five,	5 to 5.25	0.31	6.00

An examination of the figures in the third column, shows that about the same amount of fat is lost in the whey for one hundred pounds of milk, whether the milk contains 3 per cent. or more of fat. Looking at the figures in the last column, we see what proportion of the fat in milk is lost in the whey. Thus, when the milk contains 3 to 3.5 per cent. of fat, 0.32 pound of this fat is lost for 100 pounds of milk, which is 9.55 per cent. of the amount of fat in the milk. The proportion of fat grows actually less as the milk becomes richer in fat. As a rule, the loss of fat in cheese-making is quite independent of the amount of fat in milk.

(2.) Amount of Casein in Different Milks.—In regard to the second assumption made above, that the amount of casein is practically constant in all kinds of milk, we can say that our work and the work of others does not justify the statement. As a rule, when fat in milk increases, the casein also increases, though not in quite the same proportion. Above 4.5 per cent. of fat, the casein appears to increase less rapidly than in milks containing less than 4.5 per cent. of fat. In the tabulated data given below, one can see about how fat and casein are related to each other in milk containing different amounts of fat:

Per Cent. of Fat in Milk.	Per Cent. of Casein in Milk.
3	2.10
3.25	2.20
3.50	2.30
3.75	2.40
4.00	2.50
4.25	2.60
4.50	2.70

In general, when the fat increases one-fourth of one per cent., the casein increases about one-tenth of one per cent..

Now, we wish to make use of the foregoing facts in showing that the composition of milk does necessarily influence the yield of cheese.

(3.) Increase of Cheese Yield with Increase of Fat in Milk.—We must bear in mind that the two solid constituents of milk which are chiefly concerned in making cheese are fat and casein. We have just seen that when milk grows richer in fat it also grows richer in casein, and richer milks therefore contain larger quantities of the materials that make cheese. Since the yield of cheese depends primarily upon fat and casein, and since these costituents vary in milk, it must follow that the cheese yield depends upon the composition of the milk, varying as the fat and casein in the milk vary. In the following table, we give the approximate yield of cheese for milk containing different amounts of fat, varying from 3 to 4.5 per cent.

Per Cent. of Fat in Milk.	Pounds of Cheese Made from 100 Pounds of Milk.
3	8.55
3.25	9.10
3.50	9.60
3.75	10.10
4.00	10.65
4.25	11.20
4.50	11.70

These figures show that as milk grows richer in fat the same amount will make more cheese. In average cheese-factory milk, the approximate amount of green cheese can be found by multiplying the per cent. of milk-fat by 2.7.

67. Losses of Milk Constituents in Cheese-Making.

What constituents of milk are normally lost in cheese-making? What amounts are to be regarded as normal losses? What causes the necessary losses? What conditions produce unnecessary losses?

(1.) Cheese-Producing and Whey-Producing Solids in Milk.—Of the milk constituents, most of the water, albumin and sugar goes in to the whey, with more or less of the mineral constituents, together with small amounts of fat and casein. We may, therefore, call the albumin and sugar and water whey-producing constituents, while the casein and fat are cheese-producing constituents. Of course, some water and small amounts of albumin and sugar go into the cheese. In the following table we illustrate how these different constituents of milk are distributed in the whey and cheese:

Table Showing Distribution of Milk-Constituents of 100 Pounds of Milk in Whey and Cheese.

	Pounds.	Pounds of water.	Pounds of milk-solids.	Pounds of fat.	Pounds of casein.	Pounds of albumin.	Pounds of milk-sugar.	Pounds of ash.
Milk,	100	87.00	13.00	4.00	2.50	0.75	5.00	0.75
Whey,	89.35	83.00	6.30	0.30	0.10	0.72	3.50	0.72
Cheese,	10.65	4.00	6.70	3.70	2.40	0.03	1.50	0.03

On an average, 49.5 per cent. of the milk solids goes into the whey, and 50.5 per cent. into the cheese. In poor milks, a larger proportion of the solids goes into whey; in rich milks, a larger proportion goes into cheese; in other words, milk rich in fat contains a larger proportion of cheese-producing solids than does milk poorer in fat. Put in another way, of the solids contained in 100 pounds of average factory-milk, about 6.25 pounds go into whey and 6.50 pounds into cheese.

(2.) Loss of Milk-Fat in Cheese-Making.—For 100 pounds of milk, there is lost in whey in cheese-factory work from 0.20 to 0.50 pound of fat; the average is 0.33 pound. As we have stated previously, the amount of fat lost in cheese-making is practically independent of the amount of fat in the milk used. When a cheese-maker says that he cannot make cheese from normal milk containing over 3.5 or 4 per cent. of fat without having extra large losses of fat in whey, he classes himself as an incompetent workman.

Why is it necessary to lose any milk-fat in cheese-making? We have seen that fat is present in milk in the form of very small balls or globules, distributed through the milk in enormous numbers. Now, when rennet coagulates or solidifies the milk casein throughout the mass of milk, the fat-globules are retained or imprisoned

in the solidified mass just where they happen to be at the instant. coagulation takes place. When the curd knife passes through the solid mass, large numbers of fat-globules are exposed on every cut surface, and many of these fall into the whey and so are not retained in the cheese.

What conditions contribute to loss of milk-fat in cheese-making? In abnormal milk, when the casein is small in amount in proportion to fat or when it fails to coagulate normally, there are extra losses of fat. Any condition that interferes with complete coagulation by rennet, such as marked dilution of milk by water, presence of preservatives like salt, formalin, etc., is likely to increase loss of fat. Jarring or stirring the milk after coagulation has commenced and before it is completed results in increased loss of fat. Other conditions causing abnormal losses of fat are cutting the curd when it is too soft or cutting it too fine; violent, careless and rapid motions of knife in cutting curd; heating curd too rapidly or too high; piling curd too much; putting curd to press too warm; too rapid application of pressure in cheese hoop. Fermentations producing floating curd, excessive acidity of milk and forms of fermentation that dissolve casein also contribute to losses of fat in cheese-making.

(3.) Loss of Milk-Casein in Cheese-Making.—The casein lost in cheese-making is probably lost mostly in the form of fine particles of coagulated paracasein, which pass through the strainer when the whey is removed from the curd. These minute particles can readily be seen by letting a pail of freshly-drawn whey stand until the curd particles settle, and then pouring off the whey, when a noticeable quantity of finely-divided curd can be seen at the bottom of the pail. This passage of curd into whey is not entirely avoidable, but is made needlessly greater by careless or violence in cutting curd and in subsequent handling, by agitation while drawing off the whey and by imperfect strainers. Any condition that interferes with the complete coagulation of milk-casein by rennet causes loss of casein. Some forms of fermentation convert the casein into compounds not acted on by rennet or dissolve the curd after coagulation, and thus cause a loss of 0.10 to 0.15 pound of casein, and this loss appears to be quite independent of the amount of casein in the milk.

68. Relation of Composition of Milk to Composition of Cheese.

It was formerly believed that cheese of the same composition is made from all kinds of milk. On this assumption the partial skimming of milk for cheese-making was defended.

(1.) In Normal Milk.—In the following table, we present some figures showing how the change in composition of milks affects the

composition of the cheese made from those milks, the conditions of manufacture being the same:

Per cent. of fat in milk.	Per cent .of water in cheese.	Per cent. of fat in cheese.	Per cent. of paracasein compounds in cheese.
3	39.4	32.2	23.4
3.25	39.0	32.9	23.1
3.50	38.1	33.9	23.0
3.75	37.5	34.7	22.8
4.00	37.3	35.2	22.5
4.25	37.0	35.7	22.3
4.50	36.5	36.3	22.2

These figures show that in cheese made from poorer milk, the cheese contains in 100 pounds more water and more paracasein and less fat. As the milk grows richer in fat, the fat in the cheese increases in proportion to water and paracasein compounds. Hence, it is very clear that the composition of cheese is dependent upon the composition of milk, provided, of course, the cheese is made in a normal manner, so as to avoid excessive losses of fat.

(2.) In Skim-Milk.—In what respect does cheese made from normal milk differ from that made from milk which has had more or less of its fat removed? First, let us see in what way removal of fat from milk affects the composition of the milk. We will illustrate by taking milk containing 4 per cent. of fat and 2.50 per cent. of casein, and remove from the milk varying amounts of fat. The results are indicated in the following table. We assume here that we simply remove fat without any other constituents:

	Pounds of fat removed from 100 pounds of milk.	Pounds of fat left in 100 pounds of milk.	Pounds of casein in milk.	Pounds of casein for one pound of fat.
Normal milk, ...	0	4.00	2.50	0.63
Skim-milk, ...	0.50	3.50	2.50	0.71
Skim-milk, ...	1.00	3.00	2.50	0.83
Skim-milk, ...	1.50	2.50	2.50	1.00
Skim-milk, ...	2.00	2.00	2.50	1.25
Skim-milk, ...	2.50	1.50	2.50	1.67
Skim-milk, ...	3.00	1.00	2.50	2.50
Skim-milk, ...	3.50	0.50	2.50	5.00
Skim-milk, ...	4.00	0	2.50	....

With additional removal of fat from milk, the fat in milk decreases constantly, while we represent the casein that remains as being the same, though in actual practice it would increase a little. While

in the normal milk the casein is very much below the fat in quantity, the casein gradually becomes nearer in amount to the fat until they are equal, after which further removal of fat steadily reduces the amount of fat below that of casein. These changed relations are shown in the last column. In normal milk, there is for one pound of fat less than two-thirds of a pound of casein. When 1.5 pounds of fat have been removed from the milk, the amounts of fat and casein in the resulting skim-milk are just equal, or as one to one. After taking out 3 pounds of fat from 100 pounds of milk, we have left in the resulting skim-milk two and one-half times as much casein as fat, and, with the removal of 3.5 pounds of fat, the remaining skim-milk contains five times as much casein as fat. We have already seen above what effect this has on the composition of cheese made from such milk. The casein and water rapidly increase in the cheese, while the fat decreases. The tabulated figures below give the practical composition of cheese made from some of the milks represented in preceding table:

	Pounds of fat removed from 100 pounds of milk.	Pounds of fat in 100 pounds of milk.	Per cent. of fat in cheese.	Per cent. of water in cheese.	Per cent. of paracasein compounds in cheese.
Normal milk and cheese,	0	4.00	37.3	35.2	22.5
Skim-milk and cheese, ...	1.00	3.00	31.4	37.4	26.2
Skim-milk and cheese, ...	2.50	1.50	19.0	44.4	31.6
Skim-milk and cheese, ...	3.50	0.50	7.3	50.7	37.0

(3.) In Milk Containing Added Cream.—The addition of cream to normal milk has, both upon the milk and the cheese made from it, an effect contrary to that produced by removing fat from milk. The greater the amount of cream added to normal milk, the greater will be the proportion of fat, both in the milk and in the cheese made from it, and the less in proportion will be the casein and water in both the milk and the cheese.

69. Composition of Milk in Relation to Quality of Cheese.

It has been well established that the relation of fat to casein in milk governs, to some extent, the commercial quality of the cheese, other conditions being the same. How closely dependent quality of cheese is upon the relation of fat to casein in milk we cannot say in all cases. Starting with extremes, we know that the character of skim-milk cheese, which is mainly casein and water and

salt, is very different from that of whole-milk cheese. Skim-milk cheese is usually lacking in fine cheese flavor and is more often "off" in flavor, and usually contains abnormally large proportions of water. It acquires bad flavors easily. It is usually imperfect in texture and "corky" in body. We also know that cheese made from milk containing added cream is superior in flavor and other palatable qualities to that made from normal milk. As a rule, cheese made from the milk of Jersey or Guernsey cows is superior to that made from the milk of Holstein cows. In general, the greater the proportion of fat to casein in milk the better is the quality of the cheese made from such milk.

70. Standard of Composition for Whole-Milk Cheese.

How can we distinguish whole-milk cheese, commonly called "full creams," from cheese made from partially skimmed milk? As a rule, cheese made from normal milk will rarely be found to contain less than 32 per cent. of fat, even in the green cheese, and, of course, much less likely to when it comes into market after losing considerable moisture. Cheese made from normal milk would be apt to contain less than 32 per cent. of fat only in case of some abnormal conditions of manufacture, by which the cheese was made to contain an excessive amount of moisture or lose an excessive amount of fat in the process of making.

Then, again, if we take the solids of the cheese as a basis for a standard, we find that rarely, if ever, does cheese made from normal milk have its solids consist of less than 50 per cent. of fat. Taking the solids of average cheese, leaving the water out of consideration, we have in 100 pounds of cheese 35.2 pounds of fat, 22.5 pounds of paracasein compounds, and about 5 pounds of salt, ash, etc., making a total of 62.7 pounds of solids in 100 pounds of cheese, the rest being water. Now, of the 62.7 pounds of solids in 100 pounds of cheese, 35.2 pounds are fat, and this amount is 56 per cent. of the total solids. In this case the fat would have to drop below 31.5 per cent. in the cheese in order to be 50 per cent. of the total solids of the cheese.

71. Methods of Paying for Milk for Cheese-Making.

Until ten years ago or less, the universal custom prevailed of paying for milk at cheese factories by weight alone. This method was based upon the erroneous supposition that, for the purpose of making cheese, milk is milk, and that all kinds of milk are of equal value for cheese-making. The data presented in the preceding pages show by overwhelming evidence that these suppositions

are false. We know that milk varies greatly in its composition and that the cheese-making value of milk varies with its composition.

In paying for milk for cheese-making, absolute fairness can be realized in every individual case only by a careful, direct determination of both fat and casein, the two solid constituents of milk that make cheese, but this is not practicable. However, fat in milk alone can be used as a fair basis in determining the value of milk for cheese-making, for the reasons (1) that the amount of cheese made from different milks is nearly, not exactly, in proportion to the amount of fat present in milk, and (2) that cheese made from milk rich in fat has a higher quality and market value than cheese made from milk poorer in fat.

When milk is paid for by weight alone, each patron receives the same amount of money for 100 pounds of milk, without any regard whatever for the composition of the milk or the amount of cheese it will make. The amount of cheese made from 100 pounds of each kind of milk specified in the table below is the sum of 8.55 pounds and 10.40 pounds, or a total of 18.95 pounds, which, at 10 cents a pound, brings 189.5 cents. This is divided equally between the two patrons, because each furnishes the same amount of milk. Hence, each receives 94.75 cents for the cheese made from his milk.

	Pounds of fat in 100 pounds of milk.	Pounds of cheese made from 100 pounds of milk.	Amount of money received when divided according to yield and composition of cheese, or on fat basis—Cents.	Amount of money received when divided according to weight of milk furnished—Cents.
A,	3	8.55	82.1	94.75
B,	4	10.40	107.4	94.75

When payment is made by the weight-of-milk method, A receives the same amount of money for 8.55 pounds of cheese that B receives for 10.40 pounds; A receives over 11 cents for each pound of the cheese made from his milk, while B receives only 9.1 cents a pound for the cheese made from his milk. A receives 31.6 cents for each pound of his milk-fat, while B receives only 23.7 cents for each pound of his. A receives for 100 pounds of milk 12.65 cents, which belongs entirely to B, because this extra money comes solely from the additional amount of more valuable cheese produced by the milk of B. One method makes no difference in the value of the milk furnished, while there actually exists a difference of 25.3 cents for 100 pounds of milk in favor of B. Estimated for a season, the difference be-

tween the dividends of A and B should be not less than $7.50 for each cow. That gross injustice is inevitably done, when milk is paid for by the weight-of-milk method, must become too obvious to require further discussion.

72. Calculating Dividends on Milk-Fat Basis at Cheese Factories.

In section 46, p. 602, details were given, showing how to calculate dividends at creameries when payment is made on the basis of the milk-fat. The same method applies in all details to the calculation of dividends on the milk-fat basis at cheese factories.

73. Composition of Whey.

Whey varies in composition according to the composition of the milk from which it comes and also according to the conditions of manufacture employed in cheese-making. The following table gives the extremes and average of composition of whey, as found in New York State cheese factories:

	Average.	Highest.	Lowest.
Per cent. of water,	93.04	93.57	92.48
Per cent. of total solids,	6.96	6.43	7.52
Per cent. of fat,	0.36	0.23	0.55
Per cent. of casein,	0.10	0.15	0.05
Per cent. of albumin,	0.72	0.90	0.45
Per cent. of sugar,	4.00	4.50	3.50
Per cent. of lactic acid,	0.20	0.25	0.16

In comparison with skim-milk and buttermilk, we notice in whey a smaller amount of casein and a little more fat. Whey may be used as food for calves and pigs, but is better used when sweet and in connection with other foods. The feeding value of whey has been estimated to be about seven cents per 100 pounds. It is a good plan to sterilize whey in the whey-vat and keep the vat as clean as possible.

74. Composition of Cheese.

We have already studied to some extent the variations found in the composition of cheese and the causes of these variations, as they are related to the composition of milk and conditions of manufacture. In the table following, we will give the average composition of cheese in the green condition and the same when ripened in condition for consumption:

	In green cheese—Per cent.	In ripened cheese—Per cent.
Water,	[illegible]	31.75
Solids,	63.20	68.25
Fat,	33.75	36.75
Paracasein, etc.,	23.75	25.50
Ash, etc.,	5.70	6.00

75. The Value of Cheese as Food.

There is more or less prejudice against cheese as an article of diet on the ground of its being indigestible. This prejudice has arisen, undoubtedly, because skim-milk cheese and uncured whole-milk cheese are difficult of digestion. Many of our American people want something very mild in flavor and pretty solid in consistency. They find these conditions in cheese partly cured and in well-made skim-milk cheese. For the average stomach, cheese should be cured two months or more, according to the temperature, before it is eaten. People should be taught to eat only well-ripened cheese. The test of the proper ripeness of cheese is that a piece placed on the tongue and held a little while dissolves completely. By curing at low temperatures for longer periods of time, it is easily possible to produce cheese showing this behavior and at the same time having a mild flavor. We will briefly consider some of the strongest claims cheese has as an article of diet.

(1). Cheese is One of Our Most Concentrated Foods.—Taking various common foods, and considering the amount of water and waste portions present in them and the amount of actual food materials contained in them, we can present the following figures:

	Pounds of water and waste material in 100 pounds.	Pounds of actual food material in 100 pounds.
Fresh fish,	90	10
Oysters,	88	12
Chicken,	83	17
Hens' eggs,	76	24
Round beefsteak,	71	29
Potatoes,	67	33
Ribs of beef,	65	35
Tenderloin beefsteak,	60	40
Bread, white,	45	55
Cheese,	33	67

These figures show very clearly that, of our more common foods, cheese is among the most highly concentrated.

(2.) Cheese is One of Our Cheapest Foods.—Taking average market prices and computing the price we pay for actual food materials, excluding water and waste, we have the following figures, as representing the cost of one pound of actual food material in the foods given:

Fresh fish,	$1 30
Oysters,	1 25
Chicken,	82
Eggs,	62
Ribs of beef,	50
Tenderloin beefsteak,	44
Round beefsteak,	42
Cheese,	22

(3.) Cheese furnishes a larger amount of protein than any other ordinary available food excepting canned and dried meats. Protein is an extremely valuable food constituent, furnishing, as it does, material for lean flesh, albuminoids, nitrogenous compounds of the blood, nerve tissues, tendons, skin, hair, etc. No other food element can take the place of protein. Cheese contains about one-fourth of its own weight of protein. The cost of protein in cheese is probably less than in any other food material, speaking of our American cheddar cheese retailing at 15 to 20 cents a pound.

CHAPTER XI.

METHODS OF TESTING MILK AND ITS PRODUCTS.

76. The Need of Tests.

It is necessary to ascertain the amount of some of the constituents of milk and of its products in order that we may be in position to judge the value of the materials in question for one purpose or another. Thus, at creameries, cheese factories and milk stations, it is necessary to determine the amount of fat in each patron's milk, in order to pay for the milk on the basis of the fat content. It is necessary for a dairyman who would be progressive to know the amount of fat in the milk of each individual cow of the herd, in order to know what the value of the cow is to him; because, only by

such knowledge can one obtain the most profitable herd. Frequently, in making butter, it is desirable to know the amount of fat present in cream, also in the case of selling cream. Then, it is necessary, in butter-making, as previously pointed out (see section 28, p. 44) to determine the amount of acid in cream, frequently, also, in selling milk, in order to ascertain the approximate age of milk when it is received by the retailer. Another form of test that dairymen have occasion to make, especially where they purchase milk from other parties, is the estimation of solids in milk to find out if the milk has been adulterated by addition of water or by removal of fat. From these preliminary statements, it can readily be seen how important a part the testing of milk and its products plays in the problems which the dairyman constantly has before him.

77. The Babcock Test.

The Babcock test is a method for determining the amount of fat in milk and its products. It was devised in 1890 by Dr. S. M. Babcock, chief chemist of the Wisconsin Experiment Station. It is probably not too much to say that, in giving to dairymen this simple method of finding out how much fat a sample of milk contains, Dr. Babcock made the greatest contribution to the real progress of dairying ever made by any one man. There are other tests which are, more or less, imitations of the Babcock test, but none that, in all respects, equals it.

In general, this test is based on the action of strong sulphuric acid upon milk-casein, albumin and milk-sugar, by which the milk-fat is released from the influence of these other compounds and thus is free to collect in one separate mass. In order to hasten the complete separation of the fat from the rest of the liquid, centrifugal force is employed.

78. Advantages and Disadvantages of the Babcock Test.

Before describing in detail the method of employing the Babcock test, it is desirable to call attention to the special points of its merits and demerits.

(1.) Advantages.—(a.) The apparatus and materials are inexpensive, both in respect to first cost and also cost of making tests. (b.) The test is accurate enough for all practical purposes, giving the real per cent. of fat within two-tenths of one per cent., comparing most favorably with the most accurate laboratory methods. (c.) The test is quickly made, requiring less than fifteen minutes. (d.) The operation of the test is simple and easy. Only one chemical is used and no chemical training or knowledge is necessary to operate it.

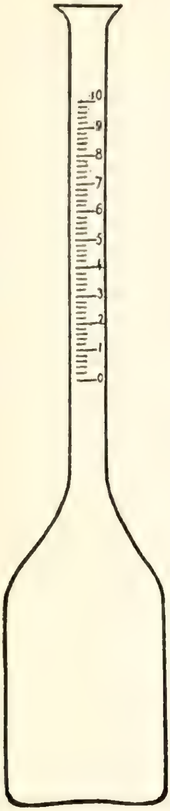


Fig. 8. Milk bottle.

Fig. 9.
Pipette.

Fig. 12.
Greiner's
Pipette.

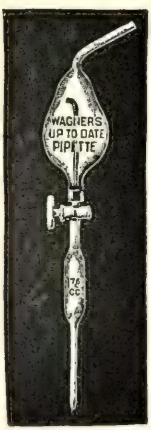


Fig. 11.

Fig. 10. Acid measure.

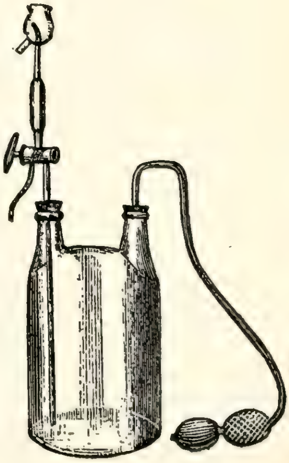


Fig. 13. Acid bottle.

(e.) The percentage of fat in each case is shown directly to the eye without special calculations or reference to tables. (f.) Only a small amount of milk is required to make the test. (g.) The apparatus does not readily get out of order and chances for accidents are absent with properly made machines. (h.) One sample or a large number of samples can be tested at the same time with the same facility. (i.) The results can be easily confirmed by repetition of tests. (j.) Completed tests can be set aside and will keep for future reference for a long time, if desired. (k.) The accuracy of the apparatus employed can be easily ascertained. (l.) Sour milk can be correctly tested, provided it can be correctly sampled. (m.) The test can, with some little modifications, be used in determining the amount of fat in cream, skim-milk, buttermilk, whey, condensed milk and cheese. (n.) The test is applicable to all kinds of milk of which good samples can be obtained, without regard to breed or other conditions.

(2.) Disadvantages.—(a.) Sulphuric acid, which is used in the test, is a dangerous substance, if handled carelessly. Therefore, its use requires constant attention and caution. (b.) The strength of the acid must be uniform and so must be examined from time to time. (c.) The speed of the centrifugal machine used must be properly regulated in order to secure correct results. (d.) The temperature of the milk at the beginning and end of the test must be controlled. (e.) The graduated glassware is sometimes incorrect. (f.) Attention must be carefully given to every detail of the operation, if correct results are to be obtained. These disadvantages, it will readily be seen, are all easily overcome. They are all practically summed up in the one requirement that careful attention must be given to all details. Any person who cannot be careful should not try to use the Babcock test in responsible work, much less should he try to use any other; in fact, such a person has no place in a creamery or cheese factory or in any dairy operations.

79. Description of Apparatus and Materials Used in Making Babcock Test.

(1.) Test Bottles.—The form of bottle used in this test is shown in Fig. 8. The neck is so graduated that each division represents two-tenths of one per cent. and five of the divisions represent one per cent. when 17.5 cubic centimeters or 18 grams of milk are used in the test. The graduation extends from 0 to 10 per cent., a range sufficient for all ordinary work with milk. When cheese or cream is tested for fat, a bottle like that shown in Fig. 18 or 19 is used. When skim-milk, buttermilk or whey is to be tested, bottles like that shown in Fig. 20 or 21 should be used according to directions given hereafter.

The divisions on the neck of the bottles should be uniform and the lines run straight across the neck, and not obliquely. When the numbers or lines become indistinct from having the blackened portions washed off, they can be restored by rubbing over the scale with a lead pencil or with a cloth having a little black paint on it. Each bottle should be numbered. A convenient way is to have the number stamped on a copper ring and slip this over the neck of the bottle.

The accuracy of the scale on the neck of the bottle can be approximately tested as follows: Fill the bottle to the mark with water, wipe out the neck of the bottle with a piece of filter or blotting paper and then measure into the bottle 2 c. c. of water with an accurate pipette; this should fill the bottle to the 10 per cent. mark. If bottles vary more than 0.2 per cent. in the whole length of the scale from 0 to 10 per cent., they should not be used.

(2.) Pipette for Measuring Milk.—A pipette like that shown in Fig. 9 is the form commonly used. This should hold 17.6 c. c. when filled to the mark. This will deliver about 17.5 c. c. of milk or 18 grams. It is important that the pipette should be accurate and should hold exactly the amount stated above. Other forms of pipette for measuring either milk or acid are shown in Figs. 11 and 12.

(3.) Measure for Acid.—A cylinder of glass like that shown in Fig. 10, with a lip to pour from and a single mark at 17.5 c. c. is the form commonly used. It is not necessary that this measure should be completely accurate, since the amount of acid used can be varied a little without affecting the test. In Figs. 13 and 14 are shown automatic pipettes which may be used to advantage where a large number of tests is made daily. This apparatus saves much time but has the disadvantage of being somewhat expensive and readily broken unless carefully handled. The automatic pipettes shown in Figs. 11 and 12 will probably be found to be the most convenient for the majority of those who use the test.

(4.) Centrifugal Machine.—Various forms of centrifugal machines have been devised for this work (see Figs. 15, 16 and 17). A wheel less than twelve inches in diameter should not be used and it need not exceed twenty inches. A wheel measuring twelve inches in diameter should be made to revolve 1,200 times per minute, while, for those of larger diameter, a smaller number of revolutions will suffice, but not less than 700 revolutions per minute should be used for the larger ones. It is better to use a machine in which the motion is transmitted by cog wheels, since, when the motion is trans mitted by belt or friction, there is danger of slipping; and the result is much less motion than is intended and an imperfect separation

Fig. 14.

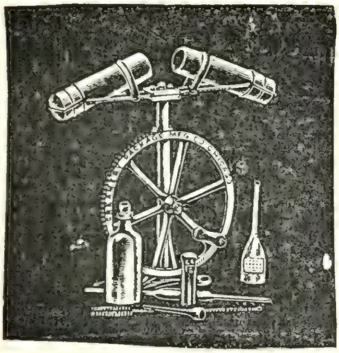


Fig. 15. Small-sized tester.

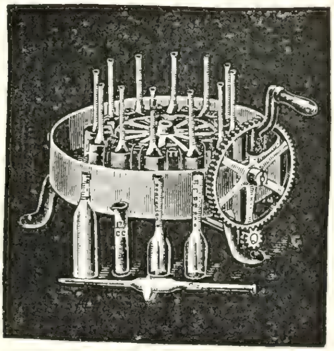


Fig. 16. Hand tester.

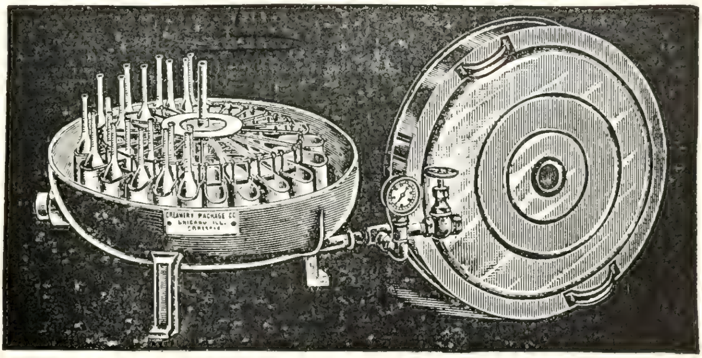


Fig. 17. Turbine steam tester.

of fat. Machines which carry an even number of bottles are to be preferred. The best form of machine for use in factories is a steam turbine machine. They have the advantage of maintaining an even speed, they keep the bottles hot and supply distilled water for filling.

(5.) Commercial Sulphuric Acid (Oil of Vitriol).—This should have a specific gravity of 1.82 to 1.83. If the acid is much stronger, the fat will be dark in color and its amount hard to read. If the acid is weaker than 1.82, there is liability of some casein remaining undissolved and this will mingle with the fat and make the test unsatisfactory. If the acid is too strong, good results may be secured by using less. It is best to purchase acid at 1.82 or a trifle above and not attempt to dilute the strong acid. Dairy-supply houses should keep acids of the right strength made up in carboys for the trade. The acid should be kept in tightly stoppered bottles, because, if exposed to air, it rapidly absorbs moisture and becomes too weak. The stopper should be of either glass or rubber and, in no case should a common cork be used, since it would be quickly destroyed by the acid. Sulphuric acid is extremely corrosive and is dangerous to handle except with care. It quickly ruins clothing or leather on which it falls and seriously burns the skin if left in contact with the acid for a few minutes. If sulphuric acid gets upon the skin anywhere, it should be immediately and thoroughly washed with abundance of water. Too great care can not be exercised in handling this acid.

80. How to Sample Milk for Testing.

(1.) Conditions Making Sampling Difficult.—Milk that has soured and thickened or in which cream has risen and dried, so as to form a clot or skin, is difficult to sample properly and will generally be found to give low results. The same is true of milk in which the fat has been partially churned and formed into little butter granules that rise quickly to the surface. Such churning is liable to occur in milk that is transported long distances in vessels that are not full. However, these difficulties are seldom met in milk that has received careful attention in its preliminary handling.

(2.) How to Take a Sample of Milk for Testing.—The sample to be tested is thoroughly mixed by pouring the milk from one vessel to another two or more times, thus making every part of the milk contain the same amount of fat. If the pipette is not dry, when used, it should be filled with the milk to be tested and then thrown away before taking the sample for testing. The measuring pipette (see Fig. 9), is at once filled with milk after the mixing by sucking up the milk into it, until it reaches above the mark on the stem of the pipette. Then the forefinger, which must be dry, is quickly

placed over the upper end of the pipette before the milk runs down below the mark. A little practice will be required to do this. By lightening the pressure of the finger on the end of the pipette, the milk is allowed to flow out until it just reaches the mark on the stem. If the pipette is correctly made, the quantity of milk in the pipette is just 17.6 cubic centimeters.

81. Running Milk Sample into Test Bottle.

Having the pipette containing just 17.6 c. c. of milk, we now hold the pipette obliquely, placing its point in the neck of the test bottle and the milk is allowed slowly to flow down the inside of the neck. Not a drop of milk should be lost in this operation. The portion of milk remaining in the point of the pipette is removed by blowing through the pipette before removing it from the test bottle. The pipette should never be held perpendicularly straight over the test bottle, running the milk straight down in, since the neck may choke up with milk and run over the top.

82. Adding Acid to Milk in Test Bottle.

(1.) Strength of Sulphuric Acid for Test.—The sulphuric acid to be used in the Babcock test must have a strength corresponding to a specific gravity not below 1.82 or above 1.83. If the acid is stronger, the fat in the final part of the test will be dark in color and its amount hard to read. If the acid is weaker than 1.82, there is danger of some casein remaining undissolved and this will mingle with the fat and make the test unsatisfactory. It is possible to secure good results with strong acid by using somewhat less, but it is best to purchase acid of just the right strength. The sulphuric acid should be kept in bottles tightly stoppered with glass stoppers, because it rapidly absorbs moisture and becomes too weak in time if exposed to the air.

(2.) Caution in Handling Acid.—If, in handling, sulphuric acid gets on the skin anywhere it should be immediately and thoroughly washed with abundance of water. Too great care cannot be exercised in handling this acid.

(3.) Measuring Acid and Adding to Milk.—When one has the samples of milk ready in the test bottles, then the acid measure is filled to the 17.5 c. c. mark, and from this is poured into the test bottles. The acid being much heavier than the milk sinks to the bottom of the bottle without mixing, the milk floating on top. Much care should be exercised in pouring the acid into the test bottle containing the milk. This is best done by holding the bottle in an inclined position, so that the acid will follow the inside walls down

to the bottom of the test bottle and not drop through the milk in the center of the bottle; and, moreover, unless this is done, the neck is liable to choke up and cause the acid to overflow on one's hands. Failure to observe this precaution will generally cause blackening of the fat. The pouring should be slow and steady. It is well, also, while pouring in the acid, to turn the test bottle around slowly so that the acid may successively come in contact with the different portions of the inside walls of the neck and wash down any milk adhering. Unless this is done, some milk may remain in the neck, in which case its casein will be precipitated and not redissolved and thus the fat will contain particles of casein.

(4.) Mixing Milk in Test Bottle.—As soon as the acid has been measured into the test bottle, the acid and milk should be thoroughly mixed. This is best done by giving the bottle a rotary motion, with gentle shaking. Much motion up and down should be avoided, since milk may be thrown up into the neck beyond the reach of the acid and undissolved casein resulting from this will mix with the fat; and ,then, violent motion up and down might throw some of the acid out upon one's hands or clothing. When the acid and milk first mix, the casein is precipitated in a more or less solid mass, which gradually redissolves. The mixing once begun should continue until one has made certain that the casein is entirely redissolved. The chemical action of the acid upon the compounds of the milk produces much heat and, as stated above, the solution, at first yellow, changes gradually through varying shades of yellow and brown to a dark-brown color, provided the acid is not too strong. This color is due mainly to the charring or partial burning of the milk-sugar by the acid. Samples of milk that have been preserved for some time with potassium bichromate or formalin require rather more time and agitation for redissolving the casein than do samples of fresh milk.

83. Whirling Test Bottles.

(1.) Whirling the Bottles.—The test bottles containing the mixture of milk and acid should be placed in the machine and whirled directly after the acid is added. An even number of bottles should be whirled at the same time, and they should be placed in the wheel in pairs opposite to each other, so that the equilibrium of the apparatus will not be disturbed. When all of the test bottles are placed in the apparatus, the cover is placed upon the jacket, and the machine turned at the proper speed, 600 to 1,200 revolutions per minute, according to diameter of tester, for about five minutes. The test should never be made without the cover being placed upon the jacket, as this not only prevents the cooling of the

bottles when they are whirled, but in case of the breakage of bottles may protect the face and eyes of the operator from injury by pieces of glass or hot acid. The machine should be frequently examined to make certain that there is no slipping of belts or frictional bearings which may cause too slow motion and result in an imperfect separation of the fat. Managed in this way no extra heat is required, as that caused by the chemical action is sufficient to keep the fat liquid. If the bottles have stood, after the acid is added, until the contents are cooled below 100 degrees F., they should be warmed to about 200 degrees F. by placing them in hot water before whirling.

(2.) Filling the Bottles with Hot Water.—As soon as the bottles have been sufficiently whirled, they should be filled only to the neck with hot water. If practical, distilled or rain water should be used for the purpose. The bottles are most conveniently filled by placing a vessel containing boiling water above the machine, and by means of a syphon made from a small rubber tube with a glass tip, run the water directly into the bottles without removing them from the wheel. The flow of water can be perfectly controlled by a pinch-cock upon the rubber tube. If only a few tests are to be made, the bottles may be easily filled with a pipette, or by pouring from a graduate. The cover should then be replaced and the machine turned for about one minute, after which the neck of each test bottle is filled with hot water to the upper limit of the scale or nearly so, and the whirling is then repeated for another minute. Unless the hot water is added in two portions, the fat is often apt to be mixed with particles of various impurities, which render the reading uncertain.

84. Measuring Amount of Fat.

After the last whirling is completed, the test bottles are removed from the machine and placed in water which has a temperature between 140 degrees and 150 degrees F. The per cent. of fat is read at this temperature. To measure the fat, hold the test bottle upright, having the graduated scale on a level with the eye; notice the divisions which mark the highest and lowest limits of the fat. The difference between gives the per cent. of fat directly. The reading can easily be taken to half divisions or to one-tenth of one per cent.

The line of division between the fat and the liquid beneath is nearly a straight line and no doubt need arise concerning the reading at this point, but, the upper surface of the fat being concave, errors often occur by reading from the wrong place. The reading should be taken at the line where the upper surface of

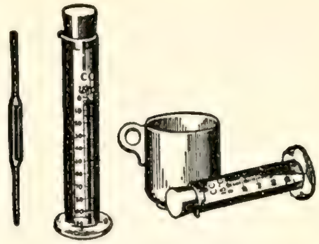


Fig. 24. Farrington's test.

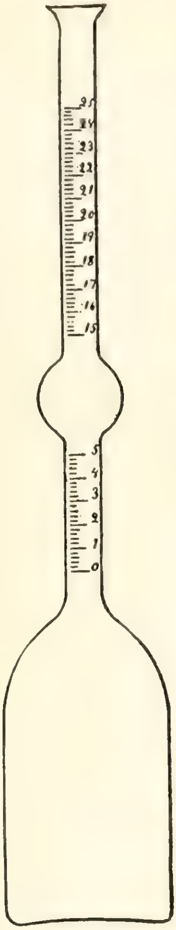
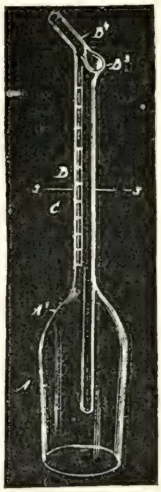


Fig. 18. Fig. 19.
Cream bottles.



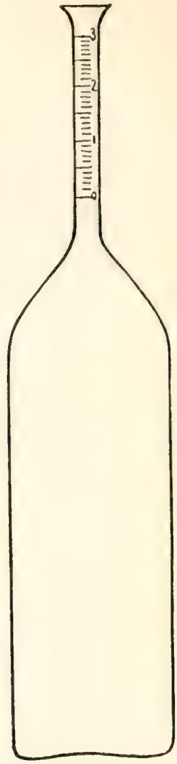


Fig. 20. Fig. 21.
Bottles for skim-milk, whey, etc.

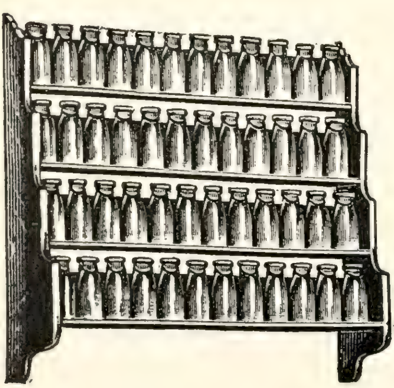


Fig. 22. Composite test sample rack.

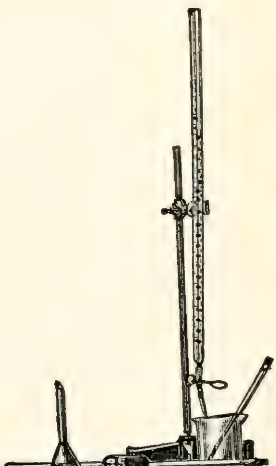


Fig. 23. Mann's.

the fat meets the side of the tube and not from the surface of fat in the center of the tube nor from the bottom of the dark line caused by the refraction of the curved surface.

The reading may be made with less liability of error by measuring the length of the column of fat with a pair of dividers one point of which is placed at the bottom and the other at the upper limit of the fat. The dividers are then removed and one point being placed at the o mark of the scale on the bottle used, the other will be at the per cent. of fat in the milk examined.

Sometimes bubbles of air collect at the upper surface of the column of fat and prevent a close reading; in such cases a few drops of strong alcohol (over 90 per cent.) put into the tube on top of the column of fat, will cause the bubbles to disappear and give a sharp line between the fat and alcohol for the reading. Whenever alcohol is used for this purpose ,the reading should be taken directly after the alcohol is added, as after it has stood for a time the alcohol partially unites with the fat and increases its volume.

Whenever the fat is not quite clear, more satisfactory results may be obtained by allowing the bottles to stand until the fat has crystallized, and then warm them by placing the bottles in hot water, before taking the reading.

If the column of fat is less than about one division, as will often happen with skim-milk and buttermilk, it may assume a globular form instead of a uniform layer across the tube; when this occurs the fat can usually be estimated with sufficient accuracy by simple inspection, but in such cases it is better to use specially constructed bottles, like those illustrated in Figs. 20 and 21.

85. Testing Cream by Babcock Test.

Accurate results can be obtained by the Babcock test in ascertaining the amount of fat in cream, but much greater care has to be taken in sampling cream. Cream that is sour, or that has been exposed to air until the surface has dried, cannot be accurately sampled. The same is true of centrifugal cream that is badly frothed. Sweet cream, from Cooley cans, that is not too thick to flow readily from the pipette may be tested with satisfactory results. The process, however, must be modified slightly from that used with milk, as the amount of fat in cream is so large that it cannot be measured in the ordinary test bottle, if the usual quantity is taken for the test, besides a much greater error results from the cream which adheres to the pipette than with milk. Both of these difficulties may be overcome by taking two or three test bottles and dividing the test sample between them into as nearly equal portions as can be judged by the eye. The pipette is then filled with

water and this is run into the tubes in the same way as the cream. If three bottles are taken the pipette is filled with water a second time and emptied into the bottles as before. This serves to rinse the cream from the pipette, and at the same time to dilute it to a point where it can be tested in the same way as milk. The bottles are then treated in the usual manner, and the reading of the tubes added together for the per cent. of fat in the cream. The necessity of dividing the sample of cream as directed above may be avoided by the use of the special test bottle shown in Figs. 18 and 19. Cream may also be tested in the ordinary bottles by diluting it with three times its volume of water and proceeding in exactly the same manner as with milk, the reading being multiplied by three.

Owing to the low specific gravity of cream, the test sample, if of the same volume, will weigh less than that of milk, and consequently the per cent. of fat as shown by the scale will be less than is found by gravimetric analysis, in proportion as the weight is less than 18 grms. Where a delicate balance is available, this error may be entirely avoided by weighing the cream used in a test, and calculating the per cent. of fat by multiplying the scale reading by 18, and dividing the product by the weight in grams of cream taken.

If 17.6 c. c. of cream are taken and the portion adhering to the pipette is rinsed into the test bottle, a close approximation of the true result may be obtained without weighing by correcting the scale reading as follows: For a scale-reading of 20 per cent., add 0.25 per cent.; for a scale-reading of 15 per cent., add 0.1 per per cent. Readings between these may be corrected in proportion. Below 10 per cent. no correction is necessary.

Cream may be tested in the ordinary bottles in the manner proposed by Mr. Winton, in Bulletin 108, of the Connecticut Experiment Station, by using a pipette having a capacity of 6.04 c. c., which will deliver about 6 grams of average cream or one third of the weight of the usual sample. When this pipette is used, about 12 c. c. of water should be added to the cream in the bottle before adding the acid. The usual amount of acid should be taken and the test completed in exactly the same way as with milk. The reading should be multiplied by three to obtain the per cent. of fat in the cream. No correction for the specific gravity is necessary when this pipette is used.

86. Testing Skim-Milk, Buttermilk and Whey.

With all products like the above, which usually contain less than one per cent. of fat, more accurate results are obtained by the

use of a special test bottle like that in Fig. 20 or 21. Less acid is required for whey than milk.

If only traces of fat appear in the neck of the bottle, the fat in the milk examined may be nearly 0.1 per cent. and this reading will be more nearly correct than estimates of from .01 to .05 per cent., which often appear in the agricultural papers. The reason for this is that minute quantities of fat are either dissolved or not separated by the method. The amount of fat lost in this way is about the same for all milks; it is compensated for when sufficient fat is present to form a complete layer across the neck of the bottle by reading to the point where the fat meets the glass instead of at the concave surface.

87. Testing Condensed Milk.

The estimation of fat in condensed milk is accomplished in exactly the same way as with cream. As a rule, condensed milks are so thick that it is impractical to measure the test sample directly with a pipette. This difficulty may be overcome by carefully diluting the milk with a known volume of water, making the analysis of this and correcting the result for the quantity of water added. The best method is to weigh the sample into a test bottle, taking about 8 grams, and after adding about 10 c. c. of water, completing the test in the same manner as with milk, the per cent. of fat being obtained by multiplying the reading by 18 and dividing the product by the weight, in grams, of the substance taken. The results are satisfactory.

88. Testing Cheese.

The examination of cheese is not as satisfactory as that of other dairy products. The chief reason for this is the unequal distribution of moisture and fat in the cheese, making it very difficult to obtain representative samples. On account of this, tests made from different parts of the same cheese, especially if it be very rich, often vary as much as two or three per cent. in the amount of fat found. To avoid this as much as possible, samples should be taken in a uniform manner.

Where the cheese can be cut, a narrow wedge reaching from the edge to the center of the cheese, will more nearly represent the average composition of the cheese than any other sample. This may be chopped quite fine, with care to avoid evaporation of water, and the portion for analysis taken from the mixed mass. When the sample is taken with a cheese trier, a plug taken perpendicular to the surface, one-third of the distance from the edge to the center of the cheese should more nearly represent the average composition than any other. The plug should either reach entirely through

or only half through the cheese. For inspection purposes, the rind may be rejected but for investigations ,where the absolute quantity of fat in the cheese is required, the rind should be included in the sample. It is well, when admissible, to take two or three plugs on different sides of the cheese and, after splitting them lengthwise with a sharp knife, take portions of each for the test.

For the estimation of fat in cheese, about 5 grams should be carefully weighed and transferred as completely as possible to a test bottle. From 12 to 15 c. c. of hot water are then added and the bottle shaken at intervals, keeping it warm, until the cheese has become softened ,and converted into a creamy emulsion. This may be greatly facilitated by the addition of a few drops of strong ammonia to the contents of the bottle. After the contents of the bottles have become cold the usual amount of acid should be added and the bottles shaken until the lumps of cheese have entirely dissolved. The bottles are then placed in the machine and whirled, the test being completed in the same manner as with milk. To obtain the per cent. of fat, the reading should be multiplied by 18 and divided by the weight, in grams, of cheese taken.

89. Testing Composite Samples at Creameries and Cheese Factories.

Provide a pint or quart fruit-jar for each patron, on which shall be a name or number distinguishing each. In each jar place about as much powdered potassium bichromate as can be held in the empty shell of a 32-oz. cartridge or about as much as one can place on a silver dime; this will keep the milk from souring. Provide a small tin cylinder holding one or two ounces of milk when filled to the brim, provided with a handle of convenient length. When a patron delivers his milk, pour it into the weighing can from a height sufficient to secure thorough mixing of the whole, and immediately, before weighing, insert the small tin cylinder, fill with milk to the brim and transfer to the fruit jar set aside for that patron's milk. In case this pouring does not mix the milk thoroughly ,then stir the milk in the weighing can with a long-handled dipper. This is repeated each day for six or seven days with the milk of each patron. Whenever a fresh sample of milk is placed in the jar, it should be mixed with the milk already in the jar by giving the jar a rotary motion. If this is not done, the cream which separates is liable to adhere tenaciously to the sides of the jar and make it difficult to take an accurate sample when the test is made. Whenever an additional sample of milk is put into a jar, it should be immediately and tightly closed. The jars should be kept in a cool place during the week. If kept too warm, the cream becomes hard and cannot readily be mixed back into the milk, which will cause low results in the test.

The quantity of potassium bichromate suggested above should be enough to keep the milk sweet for a week. In case one finds at any time that the amount does not prevent souring, then one should use more.

If milk is delivered that has firm clots of cream in it, then mix the sample in the weigh can with a dipper and take out a small portion which can be poured from one vessel to another until the clots disappear, after which take out a tin cylinder full and transfer to fruit-jar.

At the end of a week, one has in each fruit-jar a sample of milk which represents the milk delivered during that week. By testing this one sample, one secures the same results he would secure by testing the milk every day. This kind of a sample is known as a "composite sample."

90. Testing Acidity of Milk and Cream.

(1.) General Principles upon Which Acid Testing is Based.—The method of testing acidity in milk or cream is based upon the chemical action taking place between acids and alkalies. For example, if to any acid we add an alkali we change the acid and alkali both into a third compound, each of the others disappearing as acid or as alkali. Thus, suppose to some lactic acid we add some solution of caustic soda in just the right proportion, we then have neither lactic acid nor caustic soda, but a new compound formed by the union of lactic acid and sodium. To find out when a substance is acid or alkaline or neutral, that is, neither acid nor alkaline, we use some third substance, which is called an indicator. One very useful substance to use as an indicator is a chemical compound called *phenolphthalein*. When this substance is added to an alkaline solution, it turns pink, while, in an acid or neutral solution, it is colorless. For use 10 grams of phenolphthalein are dissolved in 300 c. c. of 90 per cent. alcohol, and a few drops of this are used. Now, what use can be made of these facts in ascertaining the amount of acid in milk or cream? We will illustrate: To a measured amount of cream we add some phenolphthalein as indicator, and then to this cream add some caustic soda solution, so prepared that we know just how much caustic soda it contains. We add the caustic soda, stirring the cream after each addition, until finally a pink color appears and does not go away on continued stirring. The appearance of the pink color means that enough caustic soda has been added to combine with all the lactic acid in the cream. Now, we know just how much caustic soda was required to equal the acid in the cream and from this we know the amount of acid in the cream. For dairy work, the caustic soda is prepared in

such a way that a certain amount of it equals one per cent. of lactic acid. The two common forms of acid test are those devised by Mann and by Farrington.

(2.) Mann's Acid Test.—Measure exactly 50 cubic centimeters of the cream or milk into a clean porcelain cup or a glass. Add a few drops of phenolphthalein and then let in some of the "neutralizer" (Mann's name for the alkaline solution), from a burette, previously filled to the zero point. A pink color appears, but disappears on stirring. Continue to add the alkali carefully, stirring the cream or milk all the while. It will be noticed, sooner or later, that the pink color disappears more slowly after each addition of alkali. Finally, a point is reached when the pink color does not disappear even after considerable stirring. Add no more alkali. Then look at the burette and see how many cubic centimeters of alkali have been used. Suppose 30 cubic centimeters of alkali have been required to use up or equal the lactic acid in the cream, then multiply 30 by .018 and the result is 0.54, which is the per cent. of lactic acid in the cream or milk used. (See Fig. 23.)

(3.) Farrington's Alkaline Tablet Test.—In this case, the alkali and phenolphthalein are mixed together in the form of solid tablets. In using this method, one first puts five tablets into a graduated 100 cubic centimeter cylinder and fills this up with water to the 97 c. c. mark with clean soft water, distilled water if possible. The cylinder is then tightly corked and laid on its side until the tablets dissolve. The cylinder must be kept tightly corked, so that none of the solution can be lost while the tablets are dissolving. The solution will be good to use for twenty-four hours after being prepared. Solutions more than a day old should, therefore, not be used. The solid tablets will not change if kept dry. (See Fig. 24.)

In making the test, the cream or milk to be tested is thoroughly mixed and then measured into a porcelain cup with a 17.6 c. c. pipette. This pipette is rinsed once with water, and the rinsings are added to the cream in the cup. Then a few c. c. of the tablet solution prepared as above directed are poured from the cylinder into the cream and thoroughly mixed with it. The tablet solution is added in small quantities until the pink color in the cream or milk lasts for some time. Now, look at the cylinder and see how many c. c. of solution have been used. One c. c. of tablet solution stands for .01 per cent. of lactic acid. Thus, if 20 c. c. of solution are used, there is .20 per cent. of lactic acid; if 50 c. c. are used, the lactic acid is .50 per cent.

91. The Use of Lactometers in Testing Milk.

(1.) The Specific Gravity of Milk.—By the specific gravity of milk, we mean the weight of a given bulk of milk as compared with the weight of an equal bulk of water at the same temperature. For illustration, suppose we have a vat which, when just full of water, contains exactly 1,000 pounds of water. Now, if we fill such a vat full of milk, this amount of milk will weigh about 1,032 pounds, because the milk contains beside the water in it several solid substances heavier than water. Hence, we say the specific gravity of average milk is 1.032. Since the specific gravity of milk depends upon the amount of these solids in it heavier than water, then specific gravity will be found to vary, because we know that the amount of solids in milk varies considerably. So, we find some milk with specific gravity below 1.030, while that of other milk is above 1.035. The casein, albumin and milk-sugar are heavier than water. Since milk-fat is lighter than water, the more milk-fat we have in milk in proportion to the other solids, the lower is its specific gravity. By adding cream to milk, we make its specific gravity less than that of normal milk; on the other hand, by removing fat from milk, we increase the specific gravity, because we remove what it lighter and leave what is heavier than water. The addition of water to normal milk lowers the specific gravity. Thus, it is easily possible by removing cream from normal milk to increase the specific gravity and then, by adding water in right amounts lower the specific gravity back to that of the normal milk. The addition of sugar or salt to milk increases its specific gravity. Since water used to be the most common adulterant of milk, it was thought that adulteration could readily be detected by ascertaining the specific gravity.


Fig. 25. Quevenne's lactometer and thermometer combined.

(2.) Quevenne Lactometer.—A lactometer is an instrument used for measuring the specific gravity of milk. The Quevenne lactometer has a scale divided into 25 equal parts, going from 15 to 40. Each division is called a degree. These divisions correspond to those on an ordinary hydrometer, ranging from 1.015 to 1.040. The Quevenne lactometer is graduated so as to give correct readings at 60 degrees F. For other temperatures the reading must be corrected by adding .1 for each degree above 60 degrees F., or by substracting .1 for each degree below 60 degrees F. So, when, this lactometer is used, the milk should be at 60 degrees F., or else the correction must be made. If the

Quevenne lactometer settles in milk at 60 degrees F. to the point marked 29, it means that the specific gravity is 1.029, the lowest limit allowed for normal milk. (See Fig. 25.)

(3.) Board of Health Lactometer.—Many city milk inspectors in the eastern and middle States used the so-called New York Board of Health lactometer. This does not give the specific gravity of milk directly, as does the Quevenne lactometer, but the scale is divided into 120 equal parts, the mark 100 being placed at the point to which the lactometer sinks when lowered into milk having a specific gravity of 1.029 (at 60 degrees F.), this being taken as the lowest limit of specific gravity in the case of normal milk of cows. The zero mark on the scale shows the point to which the lactometer will sink in water. The distance between these two points is divided into 100 equal parts and the scale is continued below the mark to 120; 100 degrees on the Board of Health lactometer corresponds to 29 degrees on the Quevenne lactometer, and the zero mark for both is 1, the specific gravity of water; hence, we can change the degrees on the Board of Health lactometer into degrees of the Quevenne lactometer by multiplying the readings of the Board of Health lactometer by .29. Tables are often given showing the equivalents.

(4.) Value of Lactometer in Detecting Adulterated Milk.—The value of the lactometer in detecting adulterated milk was formerly greatly overestimated. Taken by itself, the lactometer is thoroughly unreliable and misleading. Its proper use in milk inspection is simply to indicate whether a sample is suspicious and ought to be further investigated by detailed chemical analysis. As pointed out above, a milk could be both skimmed and watered and yet the lactometer would show it to be entirely normal.

(5.) Use of Lactometer in Estimating Solids of Milk.—By finding out the specific gravity and per cent. of fat in milk, it is possible, by making a few calculations, to ascertain quite closely the amount of total solids in milk and the solids-not-fat. Babcock has given useful rules for this purpose, which are as follows:

Rule 1. To find the per cent. of solids-not-fat in milk, add two-tenths of the per cent. of fat to one-fourth of the lactometer reading.

Rule 2. To find the per cent. of total solids in milk, add one and two-tenths times the per cent. of fat to one-fourth of the lactometer reading.

These rules give good results when applied to lactometer readings between 26 and 36 and to milk containing 2 to 6 per cent. of fat.

Example 1. A milk contains 4 per cent. of fat and the Quevenne lactometer reading is 32. What it the amount of total solids in the milk?

We multiply the amount of fat, 4, by 1.2; it equals 4.8. Then, we find one-fourth of the lactometer reading (32), which equals 8. Then we add 4.8 and 8 and get the result, 12.8, as the amount of total solids in milk.

CHAPTER XII.

SPECIAL DAIRY PRODUCTS.

In America most of our milk is consumed in one of the following forms: (1) Directly as milk, (2) as cream, (3) in the form of butter, and (4) in the form of cheese. To some extent, there are, in addition, special products prepared from milk for a more or less limited market. Some of these special products are finding an increasing importance in trade and others promise to become additional sources for the increased use of consumers in those special forms. In some of these special dairy products, it is easily possible for an enterprising dairyman to create a local trade.

92. Special Milk Preparations.

(1.) Blended Milk is modified normal milk, made from normal milk, (a) by adding cream or (b) by removing a limited amount of fat, or (c) by adding a limited amount of fresh skim-milk, or (d) by adding cream and skim-milk at the same time. It is a violation of the statutes of many States to sell blended milk as normal milk, except when cream has been added to normal milk. Blended milk, however prepared, is really a special preparation and should always be sold, not as normal milk, but as a special preparation with a guarantee as to its composition. The most common form of legitimate blended milk is the addition of cream to normal milk to such an extent as to bring the fat in the milk up to five per cent. The advantage of such milk is its uniformity in composition. It is usually supplied to a limited trade at higher prices than prevail for normal milk. Generally such milk is also prepared under every precaution of cleanliness from the stable to the delivery to the consumer. When thus prepared, it is often called "sanitary" milk, and each bottle is labeled with a guarantee of purity.

(2.) Modified Milk is milk so prepared as to make it resemble human milk in composition as nearly as possible. Such preparations are made in milk laboratories and their consumption is largely con-

fined to cities and hospitals. Such milk should be used only by the prescription of a physician. In general, cows' milk contained more fat and sugar, and less casein, albumin and ash than human milk. The following description serves to give an idea of how such preparations are made. The milk is cooled at once after milking, its amount of fat determined, and it is then diluted with an equal bulk of boiled water. This mixture is then run through a separator. By this process the liquid coming from the cream spout can be made to give a product higher in fat in relation to casein and albumin than in the normal cows' milk and closely approximating their amounts in human milk. To 100 pounds of this product are added about two pounds of milk-sugar.

(3.) Condensed Milk is usually prepared by evaporating water from normal milk in vacuum pans to a pasty consistency. Usually, more or less cane sugar is added to it and, when so treated, it is often called "conserved" milk. Only milk that has been carefully produced in respect to cleanliness is used for condensing. The following analyses give the composition of some condensed milks:

	Per cent. of water.	Per cent. of solids.	Per cent. of fat.	Per cent. of casein and albumin.	Per cent. of sugar.	Per cent. of ash.
Condensed milk without added sugar,	50.0	41.0	12.4	11.9	14.5	2.2
Condensed milk with added sugar,	25.6	74.4	10.4	11.8	50.0	2.2

Condensed milk is used only where fresh milk cannot be obtained, or where fresh milk is unsatisfactory in quality, and its use is, therefore, somewhat limited, but it furnishes an added outlet for the milk producer.

93. Special Varieties of Cheese.

There are made in America and Europe more than 150 different kinds of cheese. In this country most of the cheese made is the cheddar variety, but there are prepared, to a limited extent, several other kinds, some of which are successful imitations of foreign varieties of the same name. American *home-trade* cheese is usually made by the "stirred curd" or "granular" process and resembles cheddar cheese in general qualities, except that it is made to hold somewhat more moisture. *Sage* cheese is ordinary cheddar cheese containing

an extract of sage leaves, imparting a characteristic flavor and light greenish color. *Pineapple* cheese is a firm, solid cheese, pressed into a shape resembling a pineapple. *American Neufchatel* cheese is a soft cheese, with a rather high water content, made from sweet normal milk; it must be consumed at once within two to four weeks after being made. It comes into market in small round forms, covered with paper and then tinfoil. *Philadelphia* cream cheese is a soft, moist cheese, somewhat resembling Neufchatel, but is made from cream and put on the market in thin, flat cakes, wrapped in parchment paper. There are also made in America, Edam, Limburger, Swiss, Brie, Camenbert, Gouda and other varieties. *Primost* or *whey* cheese is practically condensed whey, containing added cream, and pressed in the form of brick-shaped cakes. *Cheese-Food* is a form of cheese that contains all the solid constituents of milk. It is made in Wisconsin. In preparing it, an ordinary cheddar cheese is first made and cured; to about 100 pounds of this is added whey, evaporated to a syrupy consistency, from about 1,000 pounds of fresh whey. The mixture of cheese and evaporated whey is ground to a pasty consistency and pressed into cakes of convenient size. This cheese-food has good keeping quality and is very palatable, being mildly cheese-like in flavor and sweetish in taste. There are two other preparations to which more precise attention is called, because they offer to small factories and farm dairies an opportunity for working up local trade. These are cottage cheese and potted cheese, or club cheese.

(1.) *Cottage Cheese* is known under several names, such as Dutch cheese, pot-cheese, schmierkäse, etc. Much of what comes into market is poorly made; properly made, cottage cheese is a delicious and nutritious article of diet, which can be readily eaten by many people who are unable to digest other cheese. Cottage cheese is usually made from skim-milk or buttermilk. The milk is allowed to sour, this process being hastened, if desired, by keeping the milk at a temperature of 80 degrees F. until well coagulated. If allowed to stand too long, the curd is likely to become soft and mushy in consistency and too sour in flavor, resulting in an unsatisfactory product. When well coagulated, the temperature is gradually raised and the coagulated mass is stirred, thus breaking the curd into small pieces, from which moisture is more readily expelled. The temperature is gradually raised to 120 degrees F. and the stirring is continued. When the curd is sufficiently firm, it is allowed to settle. Then the whey is removed and the curd dipped into a cloth strainer that can be suspended, and the excess of whey is allowed to drain from the curd, the process being facilitated by occasional stirring. After becoming sufficiently dry, the curd is salted

to taste, and, if a desirable article is to be made, it should have mixed into it a little cream or melted butter. It can be put up in various forms for the market, the chief requirement being that it shall have an attractive appearance.

A cottage cheese of less acid character can be made by taking milk that is only mildly sour and using a little rennet extract to hasten the coagulation. In this case the temperature used in expelling the whey need not be so high.

(2.) *Potted Cheese, or Club Cheese.*—This is on the market under various brand names, such as Club House, Canadian Club, Meadow Sweet, etc., being put up in small jars. This cheese is very easily prepared on a small scale. Take a piece of any good well-ripened cheese, pare off the rind, cut the cheese into small chunks and pass them through a meat grinding machine. To the cheese thus ground, one adds one ounce of melted butter of good quality for each pound of cheese and works it through the cheese until thoroughly incorporated. Then take small jars or jelly glasses, cover the inside with a layer of melted butter and pack into them the cheese, filling nearly level full. Then cover the exposed surface with melted butter and put over this a cover of paper. Set away in a cool place until wanted for use. The writer knows of cases where small dairy farms make cheese and put the product on to the local market in this form with great success. Any housekeeper can easily put up cheese in this way. Cheese put up in this way has, for the consumer, several advantages, since it does not dry out before being used up, is in convenient form to set directly on the table, is exceedingly palatable and is soft enough to be spread on bread or crackers, if desired.

94. Special Dairy Beverages.

The value of whole-milk, of skim-milk and of buttermilk as beverages has been long well known, supplying, as they do, readily digestible nutrition and quenching thirst, at the same time. There is one preparation of milk which deserves more attention as a common beverage that it has received, and that is koumiss, prepared from cows' milk. Its use is now largely confined to invalids, but it is a most desirable beverage for well people. In no form of preparation does milk seem so easily digestible, even in weak stomachs, as in the form of koumiss. People can drink *koumiss*, who can not use ordinary milk. It can be easily prepared in any household and any dairyman could work up a good local trade in it, after once getting a start. Many people do not like koumiss at first, but readily acquire a taste for it and become exceedingly fond of it. A good article of koumiss can be prepared, on a small scale, as follows: To three quarts of fresh milk, add three level tablespoonfuls of

ordinary granulated sugar and one fresh compressed yeast cake (Fleischmann's), or an equivalent of any other form of yeast. Stir it thoroughly and warm the milk up to 100 degrees F. to 105 degrees F., and keep it at that temperature, stirring from time to time, until the yeast begins to work, which is shown by little bubbles of gas escaping from the surface of the milk. This may require from three to five hours, according to the activity of the yeast. When the yeast is working well, pour the milk into pint beer bottles or some similar bottle that will stand pressure and has a convenient arrangement for corking. Fill the bottles only two-thirds full. Then put in stoppers and place the bottles in a warm place at 90 degrees F. to 100 degrees F. for half an hour. Then place at once in a cold refrigerator or directly on ice, laying the bottles down on their sides. In twenty-four hours, the koumiss is ready to begin to use. If one have good yeast and keeps the temperature at 100 degrees F., there should be no trouble in making excellent koumiss. Koumiss a week old is usually too acid for the taste of some people. In opening a bottle of koumiss after it is one or two days old, it is well to perform the operation in the kitchen rather than in the dining room, since there is usually such a pressure of accumulated gas in the milk that it may come out with a rush, especially if the contents of the bottle have been shaken just before opening. Milk from which half the fat has been removed or fresh separator skim-milk makes good koumiss.

COCOA AND CHOCOLATE.

By Prof. C. B. Cochran, *West Chester, Pa.*

INTRODUCTORY.

The amount of cocoa beans annually imported into the United States, and the amount of cocoa and chocolate manufactured and consumed in this country is increasing at a remarkably rapid rate. The same statement is true in regard to England, Germany and France. For example, the quantity of cocoa beans imported into Germany in 1898 was three and one-third times as great as that imported in 1886. In England, the consumption of cocoa has increased four-fold during the last twenty years. While I have not exact data for our own country, covering the same period, yet such statistics as I have been able to obtain show that the increase in the consumption of the products of the cocoa bean in the United States has kept pace with that shown in case of Germany and England.

As the cocoa industry has increased, so also has competition between manufacturers increased. This competition has led to a rather extensive adulteration of cocoa.

The literature pertaining to the manufacture and adulteration of cocoa preparations is quite extensive, consequently to give a review of the subject with any attempt at completeness would make an objectionably voluminous report. Believing that I have had fairly good opportunities for studying conditions as they now exist, particularly in our own State I have confined myself chiefly to the results of my own observations.

(1) WHY OUR FOREFATHERS HAD NO PURE FOOD LAWS.

Less than half a century ago almost the entire population of this country lived upon food that was home-grown and home-prepared. With the exception of a few articles requiring a different climate than our own for their production, such as coffee, tea, sugar, spices, etc., regarded rather as luxuries than necessities, the inhabitants of the country lived exclusively upon food of their own producing, while the dwellers of the city were supplied with the products of the neighboring farms. Provisions of all kinds were supplied in an unprepared condition and their preservation or preparation for the table was accomplished at the home. Nearly every one was personally acquainted with the various manufacturing operations nec-

essary, not only for the proper preservation of the products of the farm, but also for the converting of these products into a variety of articles of food ready for use. Even the products of foreign lands were prepared for use at the home. For example, spices were home-ground and coffees home-roasted. With the advance of civilization and the specialization of industries the preparation of our foods has gradually passed out of the home and into the hands of manufacturers. While this change has brought with it many comforts, and has rendered home life less burdensome and more enjoyable, it has also robbed us of that sense of security in the purity and cleanliness of our foods which was so greatly appreciated and highly prized by our grand parents. Because of our lack of knowledge of former methods and standards of excellence, as well as the various processes now employed by manufacturers, we are no longer capable of judging whether an article of food is pure or adulterated.

(2) WHY WE HAVE PURE FOOD LAWS.

Manufacturers of articles of food pursue their vocation for profit and are guided solely by business principles. Under the strong competition which now exists the problem that especially concerns them is to produce an article acceptable to the public at as little cost as possible, and to the solution of this problem they devote their energies. The greater the demand for the products of their factories and the cheaper the cost of production, the greater are their profits. Whether the article is pure or whether it is what the name implies is oftentimes a matter of little or no consequence provided it is saleable and acceptable to purchasers. Consequently oleomargarine is found in the market as butter, a mixture of cottonseed oil and tallow as lard; glucose syrup is made to take the name of honey, cottonseed oil is called olive oil, and milk thickened with glue passes for cream. Similar adulterations or substitutions might be named in a large variety of food products. All gradations of mixing, adulterating and beautifying are practised by manufacturers until in many cases the finished article bears no resemblance to the old fashioned home product of days gone by. To make an article saleable and to make it at little cost are the keynotes to success.

The above statement must not, however, be taken as universally true. Most reputable manufacturers cater to the best class of trade and put upon the market articles of a high standard of purity and excellence. But these same manufacturers under assumed names send out from their factories inferior articles of varying degrees of impurity to meet the varying demands of competition that exists in all classes of trade.

The various preparations of cocoa have in the past offered a rich

field for adulteration, and with the constantly increasing consumption of cocoa and chocolates the opportunity for profit through the adulteration of these articles increases with equal pace.

(3) DESCRIPTION OF THE CHOCOLATE PLANT AND ITS FRUIT.

Cocoa, chocolate and cocoa butter are prepared from the seeds of *Theobromacacas*, a very small tree belonging to the botanical order *Sterculiaceal* and native to the tropical regions of the Western Hemisphere. A striking peculiarity of the plumb is to be seen in the fact that the flowers and fruit, which it produces at all seasons of the year grow from the trunk and thickest parts of the branches, instead of developing from the youngest shoots. The flowers, which grow in clusters and are very small, have a corolla of five yellow petals and a rose colored calyx. The fruit is a five-celled pod from seven to nine inches, or more, in length and from three to four inches in diameter, nearly oval in outline, but somewhat pointed at the end opposite the stem.

As cocoa pods are not articles of commerce they are rather difficult to obtain. Through the kindness of the firm of Craft and Allen, chocolate manufacturers of Philadelphia, I succeeded in obtaining a number of very perfect pods from the island of Trinidad.

Two of these pods are illustrated in Fig. 1. The larger of these two pods is seven and three-fourths inches in length, three and one-half inches thick and eleven inches in circumference. The distance around the pod lengthwise is eighteen inches As will be observed from the photograph the surface of the pods is rather rough and provided with ten distinct grooves. These grooves represent the positions of the midribs and the edges of the five carpels or pistil leaves which by their union have formed the seed vessel.

In each of the five cells composing the pod is born a row of about ten seeds. As the fruit develops the cell walls become more or less obliterated so that on opening a ripened pod only a single cavity is seen containing five rows of seeds arranged about a central axis. This is illustrated by Fig. 2. At one end of the pod two of the seeds have been removed in order to show the central axis to which the seeds are attached. The pod illustrated by this photograph is five and one-half inches long and three and one-fourth inches thick and contained in all forty-eight seeds. The walls of the pod are from one-half to five-eighths of an inch thick and are composed of two distinct layers an outer firm horny layer of a yellowish brown hue about three-eighths of an inch thick and an inner somewhat softer and lighter colored layer about one-eighth of an inch thick.

Fig. 3 shows a cross section of a pod diminished to actual size. This photograph shows very clearly the two layers of which the walls

FIGURE 1.

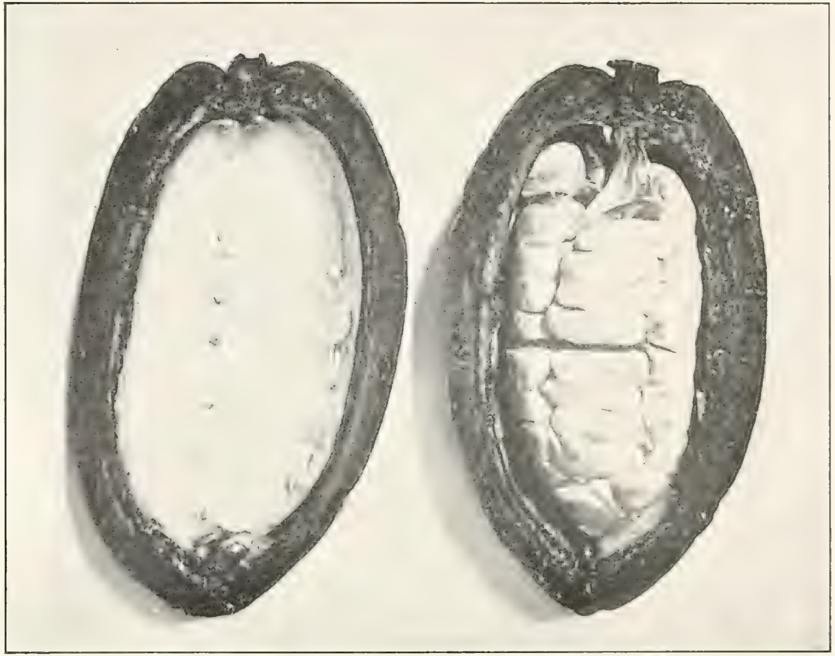


FIGURE 2.

FIGURE 3.

FIGURE 4.

FIGURE 5.

FIGURE 6.

of the seed vessel are composed. It also shows each seed attached to the central axis by a long funiculum or stalklet. As these seeds or beans, as they are usually called, form the only commercial product of the cocoa plant, they merit a somewhat extended description. The white appearance of the seeds as seen in the pod is due to a thick closely adhering cover of whitish mucilaginous pulp. When this pulp is removed the seeds are found to be nearly oval in outline and of a reddish brown color. They vary considerably in diameter, but are usually from three-fourths to one inch in length, from one-half to five-eighths of an inch wide and from one-fourth to three-eighths of an inch in thickness.

Fig. 4 shows the two surfaces exposed by a section through the middle of a cocoa bean, so cut as to show the relation between the length and the thickness of the bean, while the section in Fig. 5 shows the relative length and width of the seed. As can be seen from Fig. 4, the cocoa seed is composed entirely of seed coats and embryo. The two fleshy, much folded cotyledons or seed leaves attached to the little radicle or stem are very clearly shown in the photograph. The cultivation of the cocoa plant and the preparation of the seeds for the market form an exceedingly important and a rapidly growing industry in those parts of the tropics that are adapted to this purpose.

The harvesting and preparing the cocoa beans for market involves the following processes: 1st, the cutting and gathering of the pods; 2d, opening and removing the beans; 3d, fermenting or sweating the beans; 4th, cleaning and drying.

The taste of the bean is modified by the process of fermentation, consequently their quality and value depend largely upon the care and skill with which this operation is conducted.

(4) THE COCOA BEAN AND ITS PRIMARY PRODUCTS, COCOA HUSKS AND COCOA NIBS.

To prepare the beans for the manufacture of cocoa and chocolate, they are first roasted and then as far as possible the cotyledons or seed leaves are separated from the seed coats and radicles, the former constituting the usable portion, the latter, waste. The total loss due to roasting and waste, amounts to about 20 per cent. of the original weight of the beans. In the roasted bean, the little radicle becomes very hard and is consequently difficult to grind. In the manufacture of cocoa and chocolate, it is important that the seeds be ground to the very finest powder possible. As it is not an easy task to grind the radicles to this fine condition their presence is objectionable. After the beans are roasted, by which process their flavor is developed, they are crushed into rather coarse fragments

and then by a process of winnowing the seed coats and radicles are removed. These cleaned fragments or broken cotyledons are known as cocoa nibs and from them both cocoa and chocolate are prepared.

The seed coats of the dried and roasted beans are about one-sixtieth to one-seventieth of an inch thick, are paler in color and much firmer in structure than the bean. They are known in commerce as cocoa shells or cocoa husks. (From them is sometimes made a drink which has some resemblance in taste and aroma to chocolate.)

Analyses of the roasted husks made by various chemists indicate the following average composition.

	Per cent.
Moisture,	11.00
Fat,	4.00
Crude fiber,	15.00
Ash,	6.00
Theobromine,	.50
Proteids,	13.00
Other non-nitrogenous substances,	50.50

While cocoa nibs taken from different sources show considerable variation, the following figures represent a fair average composition.

	Per cent.
Moisture,	5.50
Ash,	3.50
Crude fiber,	3.25
Fat,	50.00
Proteids,	14.00
Starch,	8.00
Theobromine,	1.50
Other non-nitrogenous substances,	14.25

(5) CHOCOLATE AND ITS ADULTERATION.

Chocolate or plain chocolate as it is sometimes called, consists of the cocoa nibs ground to a paste and moulded into cakes. In case of sweet chocolate, sugar and frequently flavoring matters also are added. The usual methods of adulterating chocolate consist (1) in the addition of some starchy material such as corn starch, wheat flour, rye flour, ground rice; (2) the addition of cocoa husks or insufficient removal of the same; (3) the removal of a part of the fat and the substitution of other fatty material in its place.

In order to detect the usual adulterants of chocolate and to obtain a basis for estimating the amount of adulteration, the sample should be examined both microscopically and chemically. Samples of chocolate should be deprived of fat by extraction with low boiling

point gasoline or ether in order to remove the fat before subjecting them to microscopic examination. The presence of foreign starch is then very easy of detection, particularly, if the examination is made both with and without polarized light.

As is shown by the figures previously stated, there is only a very small percentage of starch found in the cocoa bean, and this cocoa starch is composed of very minute granules which could not be mistaken for the starches found in the common adulterants of chocolate.

The following table shows some of the characteristics of the starches which are of most importance in connection with this topic. The figures given under the column headed diameter represent average measurements of the larger granules.

Starch.	Diameter. Inch.	Shape.	Hilum.	Polarize.	
Cocoa,	1-4000	Round,	Indistinct,	Faintly; cross indistinct.	
Maize,	1-1500	Angular,	Distinct central crack or star,	Brilliantly, with a distinct cross	
Rice,	1-2000	Angular,	Rather distinct,	Cross distinct.	
Wheat,	1-800	Lenticular,	Invisible,	Feebly; cross faint,	Granules exceedingly variable in size; many very minute.
Rye,	1-800	Rounded,	Visible in some granules,	Dull; cross faint,	Granules variable in size.
Potato,	1-500 to 1-400	Ovoid,	Distinct at smaller end,	Polarize rather brilliantly; cross well marked.	

The starches which I have most commonly met in adulterated chocolates are those of Indian corn and wheat or rye. As all of these starches differ greatly in size and manner of polarization from the starch belonging to the cocoa bean, the detection of the adulteration is an easy matter. The percentage of starch found by chemical analysis in husked and roasted cocoa beans averages about eight per cent.

As would be expected from the definition previously given of chocolate, we find the same percentage of starch in pure chocolate as in the husked and roasted beans. Consequently if a chocolate is found by microscopic examination to contain added starch and the amount of starch in the sample be then estimated, all the starch found above eight per cent. may reasonably be regarded as due to adulteration. The substances used for adulteration in many cases, however, are not pure starch. For example, if wheat starch is found in a sample of chocolate, the substance used to adulterate the chocolate is probably wheat flour. If the starch of wheat flour is estimated by the hydrochloric acid process, the yield is found to be about seventy per cent. Consequently if the excess of starch found in a sample of chocolate adulterated with wheat flour is found to be ten per cent., this number would represent only seventy per cent. of the actual adulteration, or the amount of wheat flour would be between fourteen and fifteen per cent.

In order to detect cocoa husks in cholocate, the sample is best prepared for microscopic examination as follows: Boil a portion of the sample from which the fat has been previously extracted in dilute hydrochloric acid (about one and one-fourth of acid) for ten minutes, allow the powder to settle, decant off the liquid, wash several times by decantation, then boil for about five minutes in one and one-fourth per cent. caustic soda solution. After cooling, filter and wash. The residue is then bleached by chlorinated soda and again washed. By this treatment the dark colored and opaque tissue of the cocoa husks are rendered so nearly colorless and transparent that their microscopic anatomy is very easily seen.

If a piece of cocoa husk be soaked in water, three coats or layers become plainly visible to the unaided eye. An outer and an inner coat, each composed of rather firm opaque tissues separated by a rather thick nearly colorless mucilagenous substance forming the middle layer. Ramifying through the inner coat which is quite thick and dense are numerous fibro-vascular bundles which can be seen by the unaided eye as fine parallel ribs apparently running from end to end of the husk. When examined by the microscope this inner coat is found to be quite complex and to contain several layers of cells. One of these layers is composed of oblong, thick walled cells which form a distinguishing microscopic characteristic of the cocoa

husk. These cells are from one-one thousand to one-fifteen hundredths of an inch in length and about one-two thousand five hundredths of an inch in width.

If a sample of ground cocoa husks be prepared for microscopic examination as previously described these thick walled cells and the fibro-vascular bundles composed chiefly of small spiral vessels form very prominent and abundant objects in the field of the microscope.

If microscopic examination of a sample of chocolate leads one to suspect the presence of an undue proportion of cocoa husks, and no other adulteration is detected, the amount of husk present can be calculated by determining the percentage of crude fiber in the sample. Samples of cocoa husks analyzed in my laboratory have yielded an average of fifteen per cent. of crude fiber.

Following the method of analysis adopted by the Association of Official Agricultural Chemists of the United States, samples of roasted cocoa beans husked and ground in the laboratory have yielded about 3.25 per cent. of crude fiber. Similar figures for crude fiber have been obtained in many samples of chocolate.

If chocolate is made from cocoa ribs properly freed from husk, the per cent. of crude fiber will not vary much from 3.25 per cent. and I think this figure can safely be taken as a basis on which to calculate the amount of husk which is to be regarded as an adulterant. To illustrate, suppose a sample of chocolate yields on analysis six per cent. of crude fiber and microscopic examination shows no foreign matter other than cocoa husks. In this case the excess of husk in the sample is the amount required to raise the percentage of crude fiber from three and one-fourth per cent. to six per cent.

To produce a chocolate containing six per cent. of crude fiber would require the admixture of thirty-six pounds of pure cocoa ribs (three and one-fourth per cent. crude fiber) and eleven pounds of cocoa husks (fifteen per cent. crude fiber). Such a chocolate might, therefore, be reported as adulterated with twenty-three per cent. of cocoa husks.

(6) THE FAT OF THE COCOA BEAN.

Cocoa butter is obtained as a by-product in the manufacture of the so called breakfast cocoa. On account of the large amount of fat entering into their composition, roasted and husked cocoa beans, when ground at a comparatively warm temperature yield a thick chocolate colored liquid. This liquid consists of the melted cocoa fat in which are suspended the finely divided tissues and other products of the cocoa bean. When this liquid is poured into moulds and cooled, the product is chocolate. In order to obtain cocoa butter, the liquid is placed in canvas bags and subjected to pressure.

The oil that filters through the canvas forms cocoa butter. From the residue left in the bags breakfast cocoa is prepared which will be described hereafter.

Cocoa butter is an interesting and somewhat unique fat, both in its physical and chemical properties. It is, when fresh, slightly yellowish in color and possessed of the agreeable odor and taste of chocolate. At ordinary temperature it is quite hard and brittle, but readily melts in the mouth or when rubbed between the fingers. The readiness with which it changes from a hard brittle mass to a liquid oil is one of its peculiarities and distinguishes it from many other fats. On account of the comparatively high price which cocoa butter commands, it is not only itself subject to adulteration, but other fats are also sometimes substituted in part for it in chocolate and chocolate candies.

The adulterants of cocoa butter commonly mentioned in the text books are beef or mutton tallow, paraffin wax, beeswax, stearic acid, copraol (a fat prepared from palm nut oil) peanut oil, almond oil, sesame oil, cocoanut oil and lard.

The following table gives the most important characteristics of pure cocoa butter, and of such fats and oils as may be of interest in this connection. The figures given therein are copied from Lewkowitsch and other authorities except those marked by a star which are given from determinations made by myself or my assistant Mr. C. S. Brinton:

TABLE I.

	Butyro Refractometer Reading.	Reichert-Meissel Number.	Saponification Value.	Specific Gravity at 99 Deg. C.—Water at 15.5 C.	Melting Point—Degrees C.
Lard,	48 —52 at 40 Deg. C.,	1.3	195 —196.6	.859—.861,	36—46.
Mutton tallow,	49 —50 at 40 Deg. C.,*		192 —195.2	.858—.860,	44—51.
Beef tallow,	49 —50 at 40 Deg. C.,*	0.5	193.2—198	.860—.861,	43—48.5.
Cocoa butter,	46 —47.8 at 40 Deg. C.*	3.2	192 —202	.877,	25—34.
Cocoanut oil,	33.5—35.5 at 40 Deg. C.,	7- 7.5	250 —268	.8736,	20—28.
Ko-nut,	34.5 at 40 Deg. C.,*			.8703.*	
Palm-nut oil,	36.5 at 40 Deg. C.,	4.8	246 —250	.8731,	23—28.
Peanut oil,	62 at 40 Deg. C.,		191 —197	.916—.920 at 15 Deg. C.,	Solid point, —3 to —7.
Almond oil,	64 —65 at 25 Deg. C.,		188 —195	.914—.920 at 15 Deg. C.,	Solid point, —10 to —21.
Sesame oil,	67 —69 at 25 Deg. C.,	1.2	188 —193	.923—.924 at 15 Deg. C.,	Solid point, —4 to —6.
Cottonseed oil,	67.6—69.4 at 25 Deg. C.,		191 —196.5	.917—.925 at 15 Deg. C.,	Solid point, 0 to —1.
Oleo-stearine,	38 at 50 Deg. C.,			.869.*	54.8.*
Beeswax,	28 —30 at 62 Deg. C.,	0.3—0.5	88 —107	.821—.827,	62—70.
Paraffin wax,				0.75,	43—58.

TABLE I.—Continued.

	Insoluble Fatty Acids.	Iodine Number.	Mixed Fatty Acids.		
			Melting Point.	Butyro-Refractometer Reading.	Index of Refraction.
Lard,	93 —95	49 — 70	35 —47	22.4 at 60 Deg. C.,	1.439 at 60 Deg. C
Mutton tallow,	95.54	35 — 61	46 —54	....	1.4374 at 60 Deg. C
Beef tallow,	[illegible].1—96	35 — 44	43 —47	....	1.4375 at 60 Deg. C.
Cocoa butter,	94.6	34 — 37.5	48 —52	28,*	1.442 at 50 Deg. C.
Cocoanut oil,	....	8 — 9.5	24 —27	11.5 at 50 Deg. C.,	1.4295 at 60 Deg. C.
Ko-nut,	....	....	....	12.5 at 50 Deg. C.*	
Nut oil,	94.1	16 — 17.5	[illegible] —28.5	....	1.431 at 60 Deg. C.
Peanut oil,	95.8	87.3—103	27.7—32	....	1.4461 at 60 Deg. C
Almond oil,	96.2	93 — [illegible]	13 —14	....	1.4461 at 60 Deg. C
Sesame oil,	95.6 —95.9	103 — 111	23 —32	....	1.4461 at 60 Deg. C
Cottonseed oil	96	1[illegible]2 — 110	35 —40	....	1.4460 at 60 Deg. C
Oleo-stearin	....	18 — 26	50 —51*	24.1 at 50 Deg. C.*	
Beeswax,	....	8.3— 11			
Paraffin wax,					

(7) SOME PREPARATIONS MADE ESPECIALLY TO SERVE AS SUBSTITUTES FOR COCOA FAT.

In addition to the fats and oils commonly mentioned as adulterants of cocoa butter, I have met several fatty substances especially prepared to be used as partial substitutes for cocoa butter in chocolates and chocolate candies, or possibly also to be used as adulterants of the pure cocoa butter.

The names given to these substances and the uses for which they were intended as stated on the packages delivered to me are as follows:

1. "Oxaline. These goods are to be used in chocolate and chocolate candy together with cocoa shells. Selling price twelve cents per pound in ten pound tubs, eight cents per pound in bulk."

2. "Alberine or Sheba Butter. These goods are used in chocolate candy. Cost ten cents per pound in thirty pound tubs, seven cents per pound in bulk."

3. "Caramel Butter. Said to be used in chocolate caramels and chocolate with cocoa shells. Paid twelve cents per pound for ten pound tub. Cost eight cents in bulk."

4. "Chocola. These goods are used in chocolate and chocolate candy with cocoa shells. Paid thirteen cents per pound for ten pound tub. Cost ten cents per pound in bulk."

5. "Butter Oil, used as an adulterant in chocolate and chocolate confections."

6. "Cocoanut Oil, used as an adulterant in chocolate and chocolate confections."

The results of the analysis of the fat of these products and of a sample of pure cocoa fat extracted from roasted cocoa beans in the laboratory are given in the following table:

TABLE II.

	Reading of Zeiss Butyro refractometer at 40 Deg. C.	Index of refraction at 40 Deg. C.	Reichert-Meissl number.	Iodine number.	Saponification value.	Specific gravity at 99 deg. C.—Water at 15.5 Deg. C.	Melting point.	Insoluble fat acids.	Ether value.	C. c. n-10 alkali to neutralize one gram fat acids.	Butyro-refractometer reading of fat acids at 50 Deg. C.	Melting point of fat acids.	Acid number.	Fat acids, Index of refraction at 50 Deg. C.
								Per Ct.						
Cocoa fat,	46.8	1.4571	....	35.2	....	0.891	33	....	....	....	28	49	....	....
Alberine,	46.5	1.4569	3	35.5	200	0.8592	50	94.65	194	34.2	28.5	48	4	1.4441
Oxaline,	46.3	1.45675	2.2	44	192	0.8595	47.5	94.70	190	33.8	31.5	46	2	1.4463
Chocola,	45.5	1.4562	2.6	33.1	196	0.8555	51	94.69	192.6	35.2	26.5	48	3.4	1.4426
Caramel butter,	47.5	1.4576	....	42.6	200.7	0.8597	45	95.20	195.3	34.4	28.5	45	5.4	1.4441
Butter oil,	48.2	....	....	49.5	....	0.8925	32.9	....	....	....	29.0	44.7	5.4	....
Cocoanut oil,	34.5	....	....	8.1	....	0.9044	26.2	....	....	....	8.0	....	1.3	....

An inspection of Table No. 1 shows that the presence of either cocoanut oil or palmnut oil in cocoa fat would be indicated on analysis by the following results: (1) A lowering of the index of refraction and consequently a lower reading of the butyro-refractometer both in case of the fat and of the mixed fatty acids. (2) A lowering of the melting point of the fat, and also of the mixed fatty acids. (3) A marked diminution in the iodine number.

The presence of any of the other vegetable oils or fats mentioned in Table I would raise the index to refraction of the fat and of the mixed fatty acids, lower the melting point of the fat and of the fat acids and increase the iodine number.

The results of the analyses of oxaline, alberine, chocola and caramel butter given in Table II indicate that these fats are of animal origin and judging from the appearance of the crystals obtained from solution in ether I am led to conclude that the most important constituent of each is beef fat. The lower index of refraction, the higher melting point, and lower iodine number of chocola indicates that this fat contains a rather larger proportion of stearin than is found in the other samples. The adulteration of chocolate or cocoa butter with any one of these fats would be detected: 1st, by the elevation of the melting point; 2d, by the high temperature at which a deposit is obtained in Filsinger's test, and 3d, by the microscopic appearance of the crystals obtained when the deposit formed in Filsinger's test is allowed to crystallize from solution in ether.

The following table illustrates the effect of the addition of either oxaline, alberine, or chocola to cocoa butter so far as the above mentioned tests are concerned.

TABLE III.

	Melting Point.	Filsinger's Test.	Crystals Obtained from Solution in Ether.
Cocoa fat extracted in laboratory.	33 Deg. C.,	No deposit at 8 Deg. C., ..	Very difficult to obtain; shows very little tendency to crystallize at ordinary temperature; crystals very small.
50 per cent. cocoa fat; 50 per cent. oxaline.	42 Deg. C.,	Considerable deposit at 25 Deg. C., nearly filling liquid at 8 Deg. C.	Crystals resembling those obtained from beef fat.
50 per cent. cocoa fat; 50 per cent. alberine.	44.5 Deg. C.,	Considerable deposit at 25 Deg. C., nearly filling liquid at 8 Deg. C.	Crystals in large nos.
50 per cent. cocoa fat; 50 per cent. chocola.	45.5 Deg. C.,	Considerable deposit at 25 Deg. C., nearly filling liquid at 8 Deg. C.	Crystals resembling beef fat.

Filsingers's test is made as follows: Two grams of the fat are placed in a graduated test tube and dissolved in 6 c. c. of a solution containing four volumes of ether (sp. gr. 0.725) and two volumes of alcohol (sp. gr. 0.810), the tube is then tightly corked and the contents allowed to cool gradually. The temperature at which a deposit occurs is noted, also the amount of deposit as the temperature is lowered. In case of pure cocoa fat it is said that Filsinger's test gives a solution which remains clear even on cooling to 0° C. My own observations, however, lead me to conclude that this statement is incorrect. Filsinger's test on lowering the temperature to 0° C. has in my hands on several occasions yielded a decided deposit from cocoa fat of known purity. Furthermore, many samples of cocoa butter from different manufacturers and the fat from many brands of chocolate have given heavy deposits at 0° C. by the above named test, although no further evidence of adulteration could be detected.

This fact, however, does not detract from the value of Filsinger's test as it is not necessary to adopt so severe a standard as 0° C. It will be observed in Table III that all the adulterated samples of cocoa fat showed a decided deposit at 25° C. and at 8° C. the deposit almost filled the liquid. In any case when Filsinger's test is of value I believe a decided deposit will appear at or above 10° C., and so far as I have been able to observe, pure cocoa fat does not give a deposit at so high a temperature as this.

Additional evidence as to the character of the fat deposited by Filsinger's test can be obtained by proceeding as follows: Remove the supernatent liquid and dissolve the deposited fat in a small quantity of ether. Plug the mouth of the test tube with cotton wool and set aside until the ether has partially evaporated. In case beef fat or lard be present, a crystalline deposit will be formed which, if mounted in cottonseed oil and examined by the microscope, will show the characteristic appearance of the crystals of the one or the other of these fats. If however the sample be pure cocoa fat, there will be no crystalline deposit formed at ordinary temperatures (65° to 80° F.) until the ether has entirely evaporated. In fact, judging from my own observations, I am inclined to believe that cocoa fat does not crystallize at all from solution in ether at ordinary temperatures. The crystals which finally appear are probably due to segregation taking place in the liquid fat remaining after the evaporation of the ether.

The following table gives the results of the examination of the fat of a few samples of chocolate. The abnormal figures indicated in this table led me to regard the samples as adulterated, probably with a product of cocoanut or palmnut oil. Although such determinations as indicated in this table have been made upon many samples

of chocolate in nearly every case except those here given, the figures obtained have been within the limits of those usually quoted for pure cocoa fat.

TABLE IV.

Source of Fat.	Refractometer reading of fat, 40 Deg. C.	Refractometer reading of fat acids, 50 Deg. C.	Melting point of fat.	Melting point of fat acids.
(1) Chocolate,	43.5	24	23.3	47
(2) Chocolate,	43	....	23	46.5
(3) Chocolate,	42.5	22.3	30	41.2
(4) Chocolate,	42	24	23.5	42.6

Some samples of chocolate confections known to be adulterated gave, upon examination, the following results:

TABLE V.

Sample.	Refractometer reading of fat, 40 Deg. C.	Iodine number.	Melting point of fat—Deg. C.	Refractometer of fat acids at 50 Deg. C.	Melting point of fat acids.
No. 1,	47.5	38.2	30.5	29	44.7
No. 2,	47.2	36.9	32	28.8	47.8
No. 3,	47.1	33.2	33.5	27.8	49.9

In case of samples No. 2 and No. 3 the above results show very little evidence of adulteration. Filsinger's test also failed to furnish evidence of adulteration.

(8) GLAZING CHOCOLATE.

Much of the chocolate found upon our markets has been varnished or glazed. This process of varnishing gives a smooth glistening surface, and adds considerably to the beauty of the finished cakes. Two preparations used for glazing chocolate have come under my observation. The first was sold under the name of varnishine for glazing chocolate. Price $2.50 per gallon. The directions state that it is to be reduced with ninety-five per cent. alcohol and the chocolate cakes then dipped in this solution, or the solution painted on the chocolate with a brush.

On examination, varnishine was found to be an alcoholic solution of shellac. The second sample was sold under the name of gum benzoin shellac, at eighty-one cents per quart. It was found to be composed of gum benzoin and shellac dissolved in a mixture of common alcohol and wood alcohol.

In making cheap chocolate confections, the desired chocolate color is sometimes produced by the use of suitable coal tar colors.

A sample of Koko Brown said to be used for coloring chocolate confections, and accompanied by directions for using it, was found to be a deep brown or almost black fatty substance which, on melting, proved to be supersaturated with a coal tar color. An examination of the coloring material gave reactions indicating Soudan Brown. The melting point of the fat was 51½° C. The saponification equivalent and melting point led me to the conclusion that the fatty matter of the sample was probably stearin.

(9) COCOA.

Cocoa also frequently called breakfast cocoa, cocoa extract, cocoa powder, is prepared from the husked and roasted cocoa beans by a method which perhaps differs somewhat in detail in different factories, but may be outlined as follows:

1st. Cocoa ribs are ground to a thin paste known as cocoa liquor. 2d. This cocoa liquor is subjected to a very great pressure in canvas bags made especially for the purpose. By this operation a portion of the fat is removed, and the residue remaining in each bag assumes the form of a compact cake. The third and last operation consists in grinding these cakes to a fine powder which is now ready to be put in packages of such size and shape as the manufacturer or wholesale purchaser may desire and put upon the market under any one of the names mentioned in the beginning of this paragraph.

Analyses of the various brands of cocoa now found upon the market show a content of fat usually varying between 20 per cent. and 30 per cent., sometimes even less than 20 per cent. As the cocoa bean contains about 50 per cent. of fat, it appears that in the preparation of cocoa, manufacturers are in the habit of removing from two-fifths to three-fifths of the total fat found in the bean. This fat, which forms the by-product in the manufacture of cocoa, is moulded into cakes and sold as cocoa or cocoa butter.

The adulterants of cocoa are the same as those of chocolate and consequently do not need a separate description. The most common adulterants at the present time appear to be corn starch and wheat or rye flour.

POTATO CULTURE.

BY ALVA AGEE, *Cheshire, Ohio.*

During the eleven years from 1890 to 1900, inclusive, the potato growers of the United States produced over one thousand millions of dollars' worth of potatoes, valuing the crops at prices obtained upon the farm. The average yield per acre during these eleven years was less than seventy-seven bushels. The average receipts per acre at the farm were $34.57. If one-third of the present annual potato acreage were released to the production of clover or other profitable crop, and if the remaining two-thirds were given proper fertilization, seed and tillage, it would produce with ease 115 bushels per acre, worth $51.85. There would be no increase in total crop to depress prices, but there would be great increase in net profit per acre to the grower, and it is for this that we, as individuals, till our fields. There would be, in addition, the saving of nearly nine hundred thousand acres of good land from the annual potato acreage. Profit in agriculture must be sought in increased yields from a restricted acreage, permitting a greater percentage of arable land to lie in clover and pasture a sufficient portion of the time to guard its fertility.

This estimate of possible average yield per acre is made guardedly, and is well within bounds. Tens of thousands of growers would regard an average of 115 bushels per acre extremely low. It is an attainable average for our country, and would add many millions of dollars annually to our net profit from the crop.

PREPARING THE SOIL.

Potatoes are grown with a fair degree of success in many kinds of soil. The individual grower usually finds himself limited in choice, and may have nothing approaching a typical potato soil, which is deep, friable and retentive of moisture.

It is the desire of the writer to indicate ways by which fairly profitable yields may be secured from land that is not perfect in its adaptability to this crop, as it is so universally desired on our farms, either for home use or for market.

Physical Condition.—The first consideration in the selection of the potato field is the physical condition of the soil. That soil of the farm should be chosen which is naturally well drained, retentive of

moisture and sufficiently loose for the development of tubers, or which is capable of amendment in this respect. Experience and observation combine to convince me that the control of soil moisture is the great problem in farming, and it is true in an especial degree in respect to potato-growing.

Underdrainage.—If the land is naturally heavy and wet, underdrainage is required. There are few crops whose cash returns justify the expense of underdrainage in higher degree than the potato. If a soil would become fitted for this crop by drainage, the work can be safely advised, even for those who might find it necessary to borrow the money for the work. This is not the place for direction concerning drainage, but so many failures in potato-growing are due to an excess of water in the soil, that emphasis is placed upon the importance of underdraining any wet land that is to be given the costly seeding and tillage of the potato. The only first class material for underdrains is tile, and in most clayey sections of the country the yield of potatoes will increase with the extension of the use of drain tile.

Humus.—The control of moisture, however, is not secured in most soils merely by drainage. Deficiency in a supply at critical times in the growth of the plant is a usual cause of failure. In preparing a soil for potatoes, a leading aim should be to increase its capacity for storing moisture by the incorporation of rotted organic matter with it. The soil may be regarded as a big sponge for the holding of moisture, and its retentive character is fixed largely by its percentage of decayed vegetation. If a soil be clayey and deficient in humus, the water from rains runs off it or is evaporated from its surface, while the particles of clay adhere to each other, holding little water in a form friendly to plant growth. If a soil is sandy, the water from rains rapidly descends and passes away through the subsoil. Either class of soils is greatly benefited by the presence of decayed vegetation which stores moisture for future use of plants. Natural potato soils are rich in humus, and other soils must be made to approach them in character by the use of humus-making material.

The reader may have learned from excellent authorities that choice tubers are secured from land nearly free from humus, and it was formerly claimed by some that such land should be selected for this crop, but it was found that good yields could not be gotten in dry seasons without irrigation.

After six years experimentation with potatoes, the Cornell Experiment Station has reached this conclusion (Bulletin 196): "Where the soil is in proper physical condition the moisture may be conserved through an extreme drouth by means of frequent shallow surface tillage. But if the soil has become deficient in humus no amount of tillage is able to make good the deficiency.

"If all conditions are favorable as to rainfall and temperature, the humus problem is not so important, but if it is expected to carry a crop successfully through a season of extreme drought, as was the summer of 1900, the soil must be abundantly supplied with humus, or otherwise it will part with its moisture and the crop will suffer. Intensive tillage for best results through a series of years must be accompanied with the use of farm manures, or of green manuring. This is especially true of potatoes where best results are secured in a moist, cool soil. Abundance of humus favors both these conditions."

Rotted organic matter performs in the soil the double office of improving physical condition so that moisture may be held, air be admitted and plant roots be developed, and of furnishing plant food. Sources of such matter will be considered in their two-fold capacity.

Legumes.—Clover will fit land for potato-growing more completely than any other one plant within my knowledge. Its roots run deep and are bulky. Their habit of growth secures a fine division of clayey land, penetrating every cubic inch with fibres, and thus producing the physical condition of soil so grateful to the potato. We incline to look upon clover only as a fertilizing plant, and as such it stands pre-eminent in the sections adapted to its growth, but it is a safe statement that in a rotation of crops which includes clover and potatoes, the effect of clover upon the physical condition of the soil gives to this renovating crop half of its value. Such statement does not minimize its fertilizing value, which is unexcelled, but calls attention to another value in it often underrated.

As a purveyor of plant food, clover is first among plants. It feeds upon the free nitrogen of the air through bacteria that live upon its roots and serve it while living upon it, and through deep-running roots the clover feeds in the sub-soil where there usually is a great wealth of fertility. But clover has a way of failing. Or we may have lacked foresight, and there is not time to grow the clover before a crop of potatoes is wanted from a certain field.

There are other legumes of great value. Living near the southern border of our northern States, the writer has found it profitable to grow many acres of cow peas for plowing down for potatoes. The southern pea has its northern limitations, failing to make as luxuriant growth north of the fortieth parallel of latitude as it does in the friendly heat of the south. But it makes a good root growth and a fair amount of vine that give a rich humus, and it adds to the supply of soil nitrogen after the manner of clover. The soja bean is another renovating crop of value, growing quickly and providing a good supply of humus.

Other Sods.—A timothy sod will give good results when handled intelligently. Bearing in mind the need of the potato plant for thoroughly rotted organic matter, we may see that timothy can be made

to serve if plowed early. When the planting is to be done in early spring a timothy sod should be broken the preceding fall, and loss from winter exposure may be prevented by a seeding to rye. No inconsiderable amount of potatoes is grown in the farm and village garden and truck patch that have no proper rotation of crops, and such land always should have its winter cover crop of rye, crimson clover, rape or other similar growth.

Stable Manure.—The use of stable manure on potato land is very universally condemned by writers. When we view the ill effects only, the condemnation appears none too severe; but there is another side to the question demanding consideration. Fresh stable manure in the soil favors diseases that roughen the skin of the tubers. Our city markets bear evidence of the wide prevalence of soil diseases that reduce the value of crops, and it is the tendency of such diseases to increase and finally to cripple most seriously the industry of potato-growing. In view of this, the safe thing has seemed to be to discountenance all use of stable manure—especially that of the horse—on potatoes. But the writer shares the common experience of a host of growers that an application of farm manure, properly made, increases the net profit from potato fields, and we stop here to sift the matter for the sake of truth.

Going back to the fact that the potato wants its organic matter thoroughly rotted, we understand the good results gotten from potatoes after corn when the sod for corn has been sufficiently well manured to supply the soil for two years. The tubers are clean and thin-skinned, excelling in appearance the crop gotten where fresh organic matter abounds. It is right, then, to use manure on a crop preceding potatoes rather than upon potatoes, but the supply must be equal to the demands of the two crops, and if the first be corn, as is a common custom in some districts, that means a large supply. But I keep in mind, in this writing, the circumstances of a large class that either have land in limited amount or have manure in small supply, and are led by necessity to the planting of potatoes in land not perfectly fitted. With them the question is not what they would choose to secure perfection of conditions but what they may do to make the best of their situation. If land is lacking in physical condition, having had too heavy draft upon its supply of humus, and withal is to be planted with potatoes, it is usually wise to use a dressing of stable manure. This manure should be applied in the fall, and the best results are gotten from plowing it under to a depth of four or five inches before the middle of September in order that a winter-cover crop, like rye, may be seeded. In the spring the cover crop should be plowed down, the ground being broken deeply, and then the manure with its leachings is brought toward the surface and well distributed throughout the soil. The manure brings humus and fertility, and the soil lacking these should have the

manure even at the risk of the introduction of disease. It were far better if all land could be cared for properly, receiving its plant food and physical amendments at correct times in a wise rotation, but such conditions will never prevail universally, and hence the necessity of modification of methods outlined for perfect conditions.

Commercial Fertilizers.—A discussion of sources of organic material for improvement of soils before planting leads naturally to the subject of commercial fertilizers, and as the practical man should plan his work ahead of the plow, we discuss further the subject of fertilization before considering that part of preparation for a crop that is done with plows and harrows.

There are two methods of employing commercial fertilizers in common use. One of these is based on the belief that such fertilizers can be used profitably only in starting a crop, and preferably those crops with which seedings to grass are made. The other method involves the use of large quantities of commercial fertilizers for the constant feeding of the plants from seed-time till harvest. I forego the pleasure of a discussion of this important question except so far as it concerns the potato. Keeping in mind the necessity of net profit from the crop, we must secure all needed plant food as cheaply as possible. Most soils devoted to potato-growing, excepting now the seaboard sands that produce the early market crop, are naturally strong. That is to say, in them are stored large amounts of plant food that become available slowly. The average arable soil is a store-house of inert elements of plant food. Availability is secured in part through the growth and decomposition of crops like clover, peas, vetches, timothy, rye, etc., and the legumes also add nitrogen from the air. If a light application of commercial fertilizer of any sort will put clover or peas to work to supply the needs of a subsequent cash crop, such fertilization is rational and profitable. Such is the scheme of a majority of farmers, though its successful operation is not always apparent. There is failure oftentimes to get the full manurial crop or heavy sod, and the remaining crops of the rotation, dependent largely upon that crop or sod, are too small for best profit.

The other method involves the feeding of every crop according to its supposed needs, and necessitates an expenditure of money that a majority of farmers, selling in average local markets, would regard, possibly with reason, as ruinous. But the potato, grown near good markets, more nearly justifies such feeding than do most staple crops. Its possibilities far exceed those of the staple grains, and usually it is quickly responsive to fertilizers.

Scientists have sought a rule of universal application for the use of fertilizers. It was believed for many years that the composition of the soil, as shown by an analysis, would indicate the kind of fertilizer that should be used, but the theory would not stand the test

of practice. There are soils so deficient in some one element of plant food that safe inferences concerning fertilization may be drawn from the results of analysis, but these are not the common arable soils of the country. The chances always are that a chemical analysis would not prove helpful to a farmer. It probably would show the presence of a large amount of every element of plant food, and there information would cease. In practice one may know that the soil is lacking in available fertility, while nothing in the results of analysis would indicate such a fact.

Another scheme of fertilization was based upon the composition of the crop to be produced. The number of pounds of nitrogen, phosphoric acid and potash in a ton of potatoes is known, and it appeared reasonable that a fertilizer should approach the composition of the crop desired. This theory of fertilization is now discredited by leading scientists and by practical farmers, for two reasons: First, it fails to take into account the tons of available plant food in the soil. Land that has been given a heavy growth of clover, or a dressing of stable manure, may contain all the available nitrogen needed for the production of a full crop, while there is lack of potash or of phosphoric acid. The soil may be naturally so rich in potash that a score of crops would not exhaust the supply appreciably, and yet be lacking in available nitrogen or phosphoric acid—a lack not apparent from analysis of the soil, but apparent from results obtained when one of these elements is supplied to the growing plant.

The other reason for discrediting this theory is the rather awkward fact that experimentation shows profitable results from the seemingly excessive use of certain elements under some circumstances. A soil may be in fairly productive condition, and then give more net profit from a crop treated with twice the amount of one element found in the composition of that crop than it would from a lighter application, and at the same time another element may not increase yields at all. These puzzling results do not destroy our faith in the value of scientific investigation, but they assure us that the laws governing plant growth are not within our grasp in such degree that we can feed crops by any general formula prepared by others with assurance that we are doing the most profitable thing for ourselves. After turning to one and to another, we finally must depend upon ourselves and our own experimentation.

Station Results.—I state the matter of self-dependence thus because many are loth to give up the hope that others can save them from the trouble of farm experiments. They should understand that, so far as scientific research has gone, there is no way to know absolutely what fertilizers will pay best on a potato crop, or other crop, except by farm tests. And yet there are certain wide lines, fixed by Station results, within which we may confine our labors, and thus keep the chance of failure down to a minimum.

It is an old belief of growers that the potato is, in a peculiar degree, a feeder upon potash. It resulted that all special potato fertilizers a decade ago made potash the most prominent element. There is a reason for most things under the sun, and, in casting about for the cause of this confidence that the potato wanted potash chiefly, I am led to think that it arises in part from the known lack of potash in most sandy soils which have been devoted to potato-growing. On these soils applications of potash have been effective. It is further true that the ash of the potato is rich in potash, but in no higher degree than is the ash of some other crops. The New York Experiment Station, at Geneva, after a six years series of fertilizer experiments with potatoes, concludes that "this crop is not greatly unlike many others, including roots and forage crops, in its fertilizer requirements under given conditions."

It is known that sandy soils incline to be deficient in potash, and extensive growers of potatoes in such soils of Long Island, New York, use potash freely, having in common use a formula calling for four per cent. of nitrogen, eight per cent. of phosphoric acid and ten per cent. of potash. The correctness of this so-called Long Island formula naturally would be accepted for land of that class by reason of its general use were it not for the results gotten in the series of tests made by the Geneva Station under direction of Dr. Jordan. Very strangely the potash was wholly ineffective in some of these tests, and Dr. Jordan says: "The outcome of extensive experiments for four years on four farms presents good reasons for questioning the wisdom, under the condition involved, of applying more potash on potatoes than any other ingredient. It is now a trite saying, but a true one, that each farmer must discover for himself the fertilizer needs of his farm."

Nitrogen.—Within certain lines we may infer pretty safely the nitrogen requirements of our potato soils. Land that is very rich in humus, such as black alluvial soil, is rich in nitrogen. This element is the most costly one in a fertilizer, and an unnecessary application cuts net profits rapidly. Stable manure, made on cement or tight clay floors, and kept without waste until spread upon the land, is rich in nitrogen. Where a soil is liberally fed with stable manure the year previous to the planting of potatoes, we infer that the need of purchased nitrogen is slight. The presence of a good growth of any of the legumes is assurance of the presence of this element. In a soil rich in humus the clover may feed largely upon soil nitrogen, while under other circumstances it may get a goodly share of its supply from the air, but in either case the nitrogen is at hand if the clover or peas is present, and the percentage of nitrogen in the commercial fertilizer may be kept small under ordinary conditions.

Again, we learn to determine the content of nitrogen in a soil by humus, such as much black alluvial soil, is rich in nitrogen. This

the character of the growth. This element gives a rank growth of potato vines of a dark green color. Where the vines grow rank without application of nitrogenous fertilizers, we cannot hope to increase yields to any profitable extent by their use. Indeed, there is always danger of diminished yields as a result of excessive use of this element. This is frequently observable in old barn lots and in other spots that have had the leachings of manure. The vines grow to extraordinary size, while the tubers are very small at digging time. It may not be possible to state with certainty the cause of this phenomenon, but it has been supposed that the potato will not divert its energy to the development of tubers until the vines have reached a stage that permits the storage of some energy for this purpose, and where there is a quality in the soil inciting to extreme growth of vine, that stage of development favorable to forming tubers is reached too late in the season for good results. Be that as it may, the known fact that injury may result from the presence of an excessive quantity of nitrogen in the soil is all that the practical grower needs to place him on his guard. It is safe to say, however, that most cultivated soils incline to be deficient in this element unless stable manure or the legumes is used, and the question with the grower often is not whether nitrogen could increase yields, but whether it would do so with profit, or in what quantities could it be used in view of its costliness.

For Early Potatoes.—The nitrogen of the soil does not enter available forms rapidly in cool or dry weather. The grower of potatoes for early market usually finds it profitable to supply an available form of it to his early-planted crop to force growth before there is sufficient heat in the soil to convert its own nitrogen into forms required by plants. For this purpose the nitrate of soda is a common source. It is quickly available in the soil, and I prefer not to use it until the plants appear above ground, as the fertilizer will leach away if there are no plant roots ready to appropriate it. Slower organic forms of this element, such as tankage, dried blood, fish, etc., are desirable carriers of nitrogen for use of plants in mid-summer when decay is rapid on account of heat. It is suggested that one-third of the nitrogen be supplied in nitrate of soda, and two-thirds in dried blood, fish or other organic forms.

Nitrogen exists in unstable forms, and cannot be stored in the soil indefinitely. It wastes rapidly in the summer if no plant roots are ready to use it. If a potato-grower finds that he can use purchased nitrogen with profit, as is eminently true in the seaboard sands devoted to the early crop, it is advisable to provide part of the supply in organic forms that yield up plant food through decay as the season progresses, and to supply some immediately available nitrogen, in nitrate form, as a top-dressing during the late spring months.

Phosphoric Acid.—It is an admitted fact that most soils are relatively poor in phosphorus. Of the ten or more elements known as distinctly soil elements used by plants for making growth, only three are ever found deficient in most agricultural soils. Two only may be lacking, and oftentimes only one element. In considering the matter of fertilizing land for potatoes, I have tried to show that purchased nitrogen may pay, and it may not. Concerning this we judge by the character of growth the soil makes, and by field tests. Likewise, potash may or may not be lacking in available form. Concerning the third one of these three elements, phosphoric acid, the same may be said, but we assume that in nine soils out of every ten, if any one of these three elements is lacking, that one is phosphoric acid. If two elements are wanted, phosphoric acid will prove to be one of these two. The content of this element in the potato is small, and there remains a general impression that phosphoric acid is of minor importance in fertilization for potatoes, but a careful study of all Experiment Station tests is convincing that phosphoric acid cannot be left out of any potato fertilizer, and that the requirements for this element are wholly out of proportion to the amount actually stored in the tops and tubers of the plants. So pronounced is this that some careful experimenters have been led to say that phosphoric acid is the controlling element in a potato fertilizer. A formula for a fertilizer carrying the elements in the proportion found in the potato tuber would require four and one-half per cent. of nitrogen, two of phosphoric acid and ten of potash.

The Long Island growers have raised the percentage of phosphoric acid to 8, cutting the nitrogen to 4, and Station experimentation indicates that the formula should show a still higher percentage of phosphorus, while the potash may be cut down. The whole matter of fertilization must be left within wide lines, and the individual grower must find by farm experiment just what plant food may be given with profit to his land, but the assumption should be that any potato fertilizer should be strong in phosphoric acid. Until the opposite is proved true in the field, I should assume that this element should be the dominant one in the potato fertilizer used. The assumption is based not only upon Station experiments in sands as well as clays, but also upon the trend of opinion among those growers who test these things for themselves.

Let no reader get the impression that cropping should be done with phosphoric acid alone. Much land is being ruined to-day by such practice. But if he is a grower of potatoes he may begin experimentation with the fact that if any one element is lacking in his soil, this one probably is so lacking. Then he must learn whether he is supplying sufficient nitrogen through manures and clovers, and he must take stock of his supply of available potash in the soil, and sup

ply a need of that element, if such need exists, as is very often the case, notably with sandy soils.

Carriers of Potash.—The cheapest carrier of potash for most potato-growers is the muriate. It is a common impression that this material affects the quality of the tubers adversely, and the rather more costly sulphate is advised. In my own fields I have made some tests, selecting tubers from hills treated with the muriate, and other tubers from hills on an adjoining plat untreated, and having them cooked together under proper conditions. So far I have been unable to detect the slightest injury to edible quality from use of potash in the form of a muriate, and this has led to the study of Experiment Station tests with the result that the character of soil or season appears to be a determining factor. There is less assurance of the slightest injury to the quality of the potato from use of the muriate than would be expected from the importance that has been attached to the matter by writers. It appears that in some soils quality is affected, at least, when the potash is not applied before the planting so that the salt may be washed out by rains. In other soils there are no ill results. It is a matter easy of test for the grower, as both sulphate and muriate forms are on the market everywhere. Kainit, a low-grade sulphate form, contains so big a percentage of salt that it should be classed with the muriate in effect upon quality.

In respect to effect upon yield, it is probable that the more costly sulphate is the cheaper source of plant food for acid soils, while the muriate is most satisfactory for all other soils. The Rhode Island Station has arrived at this conclusion from the study of its own results in comparison with those of other Stations.

Ashes.—An application of hard-wood ashes usually has a favorable effect upon the yield of potatoes. As such ashes are rich in potash, this effect is doubtless one cause of the very common belief that potash is peculiarly a potato fertilizer. The truth is that ashes exert an effect upon most crops wholly out of proportion to their potash content, and therefore attributable to some other element or elements in the ashes. It is known that the lime in ashes is in an especially effective form, exerting much influence upon the soil. While, as has been stated, hard-wood ashes affect yields favorably, they promote diseases that roughen the skin of the potato, and their use is not advised except on acid soils. In some soils they also have an unfavorable effect upon the texture of the land.

Coal ashes contain practically no fertilizing qualities, but I have found that it pays to draw and spread the home supply on the more clayey parts of the potato land for its improvement in physical condition. They should be spread before the harrow, and worked into the surface soil.

Plowing the Ground.—Soils in which potatoes may be grown with profit vary so much in character and in location that no hard and fast rules can be laid down. But keeping in mind the nature of the plant and its likings, we may make our practice conform to its needs. The first consideration, as has been said, is that of soil moisture. We want conditions under which a supply may be held for times of drouth. One method of securing this is by deep plowing. The storage capacity of land is increased by deepening the soil, as that is the part of the earth that contains organic material in such form that moisture is held as in a sponge. The deeper we plow, the more soil we have of such texture that the water of rains is received and held, provided the percentage of humus is maintained by increasing the supply as we increase the number of cubic inches of soil upturned by the plow. Within certain bounds we may make this rule for our guidance: The depth of plowing should be proportionate to the percentage of humus. But the potato requires an abundance of this material, and if our soil is properly stocked with it, the plow should go deep. Depth in plowing is a relative term. I know successful growers on land that will not permit a greater depth than six inches. They feed that six inches well, and make money. Preferably, however, the plowing should be deeper. Where six inches is a normal depth, seven should be gotten if possible. Where eight inches is a usual depth, nine inches should be sought.

Kind of Plowing.—I like the rule given above respecting the depth of plowing. If a thin sod be buried deeply, and soil deficient in humus be placed at the depth the tubers shall form, a clayey soil will give disappointing results. Worst of all, a layer of soil deficient in humus, either in clays or sands, is utterly unfit material for the soil mulch that we make at the surface by tillage for the retention of moisture. If the amount of organic material be small, it should not be distributed throughout too many inches of soil by very deep plowing. It is better to sacrifice the benefits of depth under such circumstances to insure fair texture of the soil in which the tubers form and of that at the surface. This caution is for those only who from necessity plant land not well fitted for potato-growing. Where the soil is supplied with such a store of humus as the potato delights in, depth should be secured by deep plowing. It was Benjamin Franklin who said, "Plow deep while the sluggard sleeps," and while the advice is much quoted and is wise within proper bounds, I venture the opinion that if the revered author were to return to earth and note the decrease in the humus-content of our American soils he would modify the statement so far as to say that the depth should increase only with increase of humus-producing material added in sods and manure.

The Plow.—There are breaking-plows of many models. In respect to the kind needed for turning sod land for potatoes, let us reason

the matter out. Assuming that the soil needs the improvement in texture due to rotting sods, we may be sure that the best of the sod should not be buried in the bottom of the furrow. There is more talk than practice of leaving the furrow-slices on edge. This is due to the use of plows having long and curved mold-boards, and to our liking for a smooth appearance in a plowed field. The sod should be left in such position for potatoes that it can be distributed throughout the soil, a fair proportion remaining near the surface. This means the leaving of the furrow-slice on edge, and that is done only by the plow having a short and straight mold-board. This point is not appreciated by growers who have a soil naturally loose and able to remain in good physical condition without the aid of organic matter, but such soils are the exception. The short and relatively straight mold-board leaves the furrow-slice as required by the potato in ground of rather poor texture. It will not pulverize while turning the ground as does the long, curved mold-board, but that is merely one of the drawbacks of farming a soil not perfect in its adaptability to a desired crop. The plow should be set to run true on the bottom, and to turn not more than an inch in excess of what is actually cut by the point.

Thoroughness in plowing is more important for the potato than for either corn or wheat, necessary as the latter may be. The potato makes in the ground, and is more dependent upon good soil conditions than is any of the cereals. If the workman will set the plow to cut a trifle scantily and then hold against the plow-handle to offset this, the furrow-slice can be partially pulverized with a very short, straight mold-board.

Time of Plowing.—It is probable that four out of every five of my readers plant early varieties of potatoes, or else plant medium varieties early in the season. They have doubtless observed that early-plowed land retains moisture more perfectly than land plowed later in the spring. Recalling the fact that drouth is usually a factor in cutting yields of potatoes, and that the control of moisture is the first consideration, we learn that it is wise to plow early for this crop. There is less loss of soil moisture from the airing given by plowing, and there is more opportunity for spring rains to restore the close union of the top soil and sub-soil so that water may rise from below. Much as we value an addition of vegetable matter to the soil, we do not want plowing delayed until a growth of clover or rye becomes bulky and woody, as experience teaches that this bulk has robbed the ground of moisture in its growth and interferes with the rise of moisture from the sub-soil when plowed down. Early spring plowing is advisable for most land devoted to potatoes that are matured before the first of September.

Fall-Plowing.—Regarding only soil fertility, land should be kept covered by a growing crop. Bare land is losing available plant food whenever it is not locked up by frost. Hence the condemnation of fall-plowing for a spring crop. But we do not invest money in land primarily to maintain its fertility, but we maintain fertility in order that we may make money. Income must be considered. There is land of such texture that a spring-planted crop can not be produced from it in profitable amount unless it undergo the ameliorating effect of hard freezing. It cannot be put into fine physical condition after spring-plowing, while it does yield itself well to tillage when plowed in the fall and left frost-locked during winter. I am acquainted with some such land that is made to produce potatoes profitably for its local markets, and am sure that there is a serious mistake in condemning fall-plowing for it. Again, there is land now yielding good income from extra early potatoes that could not be plowed in time for the early planting if the work was delayed till spring. It loses some in fertility, but amends are made to it by the application of plant food easily purchased from the proceeds of its crops. When consistent with returns from the crop, land should not be left bare during winter. The losses from this source have been heavy in American agriculture, but there are conditions justifying some fall-plowing for potatoes, and the matter is one worthy of careful study. If seemingly best, do it, but remember that when bare and unfrozen, there is a loss of fertility that must be made good before net profit is figured.

Harrowing.—Potato land should be made fine, but not too firm. Spring rains tend to pack ground unduly for potatoes unless it is naturally very friable. The perfect harrow would be one that pulverizes each furrow-slice fast as turned, with power gotten from a horse walking on the solid bottom of the furrow by its side. I have tried to interest inventors in such a harrow, but am assured that too many farmers are indifferent to perfect work to make the demand for such a harrow attractive to a manufacturer. As it is, we plow land to make it loose, and then tramp it with horses while fining it until a considerable percentage of the soil is packed down as tight as it was before the breaking-plow was used. When the weight of a horse is placed on the few square inches of surface covered by his foot, the ground under the foot is packed. This is especially true of soil that necessarily is worked in the spring as soon as it crumbles nicely. The track of the horse fills with loose soil, hiding the damage done, but let the farmer remove the loose soil and dig into the ground that was packed by the pressure, and he will realize what is being done. It has been my rule to cut the plowed land with a twenty-inch disk harrow, drawn by three horses. Two cuttings, each lapping half, equal to four single cuttings, have been given to tear the

sod into pieces. These were followed by an Acme, and then by a plank float. An estimate of the amount of surface covered by the feet of the horses in all this work is astounding. It may be thought that the harrows repair the damage, but usually they conceal rather than mend it. In a fresh-plowed field the effect of the pressure given by the feet of the team goes much deeper than the average harrow. Indeed, thorough as my own harrowing has been, I find the firmed soil below the depth made by the extra large disks. Such pressure immediately under a hill cannot fail to do harm.

This consideration enforces the necessity of letting a soil become fairly dry in the spring before the harrow goes upon it. It also leads one to defer some of the preparation of the land until after the planting when the horses can be kept in the middles between the rows. This suggestion is made with some misgivings, knowing the tendency to slight preparation of a seed-bed, and the inclination to promise land additional work that is never given it. But I write of preparing land for an early crop, when rains are sure to firm the plowed ground sufficiently to put the sub-soil into close contact with it so that moisture can rise from below. A later-plowed field must be harrowed with thoroughness and made reasonably firm to insure against drouth, and at a later period in the spring the tramping by teams does not pack a soil so severely. But no matter how early the planting, there should be sufficient harrowing to make a soil fine. After the planting, a deep, thorough tillage can be given to complete the work of preparation. This will be discussed under another head.

It is always a mistake to plant potatoes among clods. The work of fitting with harrow and float must be sufficient to give to the piece of seed a surrounding of fine soil. The use of the plank float right after the plow, and again after the harrow, will do much to insure this state of fineness. There is no question in regard to the necessity of this much work. Some deeper tillage, however, may be deferred, provided one understands the need of it, and will give it before the young plants have sent their roots out into the soil.

THE SEED.

Success in potato-growing is dependent largely upon the seed. A large percentage of failures is attributable directly to the character of the seed. While I base what I write upon the experience gotten year after year in the culture of this crop, and upon the experiences of others, it cannot be expected that some readers will accept readily many of the statements, and to all such the request is made, in the interest of truth and their own income, that they put the doubted statements to the test of field trial. Many a farmer says that po-

tatoes cannot be grown profitably on his farm when the fault lies with the seed he has been using, and the easy trial of good seed is within his reach. There are large areas that will not grow potatoes well, and are not needed in the country's production, but most farmers should grow their home supply, and do it with some profit. This may demand a different fitting of the soil than that given heretofore, but to poor seed is many a failure attributable.

What is Good Seed?—The tuber of the potato is not the true seed of the plant; that is in the seed ball. Neither is it the root of the plant, as is the case with the sweet potato. It is merely an enlargement of an underground stem. The plant puts forth branches above ground which form blossoms, and at a certain stage of growth the plant puts forth branches, or stems, that do not come above ground and blossom, but remain below the surface, enlarge at the ends, and form that which corresponds to the blossom of the branch above ground, with the addition of starchy material stored about the cells leading to the buds, which is intended by nature for the feeding of the young plants when they are started another season. These buds, cells and stored starchy material, wrapped up in one package, is the tuber for which we cultivate the plant.

Just so sure as like produces like in this world, the tuber partakes of the nature of the vine that produces it. If that vine has grown in a heat that weakened it, or has been affected by disease or insects that lessened vigor, the tubers have a correspondingly low vitality. As we know, the potato thrives best in a cool climate. Excepting the high mountain elevations, all land south of the fortieth parallel has too much heat during some period of the growing season in normal years for the best development of the early-planted potato. It does not follow that big yields per acre are not obtained some seasons in the heart of the belt liked by our heat-loving corn plant. Our southern States grow good fields of potatoes, and yet the fact remains that the big yields are most easily gotten in northern latitudes—in Maine, New York, Michigan and the northwest. There the potato thrives in the absence of extreme heat, and has great vitality, as the size of the tubers attest.

Potatoes grown year after year under unfavorable climatic or soil conditions, decrease in vitality, and the man who clings to such tubers for planting must reap what he sows. The vines lack vigor, and the underground stems, or tubers, lack in size. Excepting high altitudes in our mountain sections, there are no sections south of the States mentioned above where the vitality of potatoes is fully maintained, and I am very sure that it would pay growers to get seed from the north every second or third year when prices are apt to be low. This statement could be put stronger by me, as I find it profitable to get seed from more northerly sections every year. But even

if a change were made every second or third year, there would be far less loss from inferior stands of plants. I refer now to all growers who plant in early spring. There are conditions under which vitality in comparatively warm latitudes may be maintained for a time by growing the seed in the cool weather of autumn, but the experience of many successful growers is corroborated by co-operative tests at the Vermont and Maryland Stations, in which the Vermont seed proved to be the better. The Missouri Station found Vermont and Wisconsin seed superior to that of Missouri, and in tests of Rhode Island and Maine seed, the latter proved the better.

Selection of Seed.—Growers have been puzzled by the contradictory evidence concerning the relative value of small potatoes for planting. Experiment Stations and individuals have gotten results from comparative tests of small and large seed that conflicted with results from other tests, and some farmers have concluded that there is no choice in size. Let us think over the matter. The tuber shares the degree of vitality possessed by the vine. It is a branch—only underground. Its size depends upon two things: the vitality of the vine and the time the tuber was formed. If it belongs to the second lot of setts made by the vine, and is small simply because it did not have time to become large before the vine matured, it comes of just as good stock as the larger tubers, of the first lot of setts, in the hill. It has good blood and can reproduce the vine that produced it. Such seed, though small, may give a maximum yield. But there is the small tuber that was part of a spindling vine, low in vitality. It is small because there was not enough good blood in that vine to make any tuber as large as it should be. It is low in vitality, as the vine was—a good-for-naught trifling—because the vine had no original vigor. There are two kinds of small potatoes. Those from vigorous vines may give good yields, while those from spindling vines are a disappointment unless highly fed by a rich soil under favoring climatic conditions. It could not be otherwise according to nature's laws, and it is not otherwise in our farm experience.

The "Runty" Potato—Too much emphasis can hardly be placed upon the distinction between the tuber of small size that has been produced by a vigorous vine and the tuber of same size produced by a weak vine. In the former instance we have a potato—an underground stem or branch—that partakes of the great vitality of the plant as evidenced by the strong branches. It failed to attain large size because it belonged to the late setts of the plant, or because the plant was late and did not have time for full growth. The tuber of the other class is small on account of the natural weakness of the vine. When small potatoes, known by growers as "seconds," are used year after year in planting, the percentage of runty individuals

increases rapidly. Nearly the entire product of the spindling hill falls into the "seconds" class. Let us suppose that in one season's planting there is only one degenerate vine in a hundred. That will not affect the yield perceptibly. Assuming that each one of the ninety-nine vigorous vines furnishes one tuber of good vitality for the "seconds" class, and that the spindling vine furnishes five tubers, we have the next year five degenerates out of a hundred and four. The next season we may expect twenty or twenty-five out of a hundred.

As a matter of thirty years observation in a potato-producing district, this rate of degeneracy is not at all unusual in the case of careless growers. I have seen crops of thousands of bushels, produced from small seed taken from a crop grown from small seed, that run so inferior in size that they were not wanted in market, while fields planted with seed of high vitality produced tubers of fine size. The seed was "run-out" through the continued use of "seconds." It is true that small tubers from spindling vines may not give a failure of crop when used for planting. It is possible to have a soil so rich and fine that high-feeding of the plants brings improvement of the stock. Equally, soil and climate may prevent deterioration of the stock when "seconds" only are used. Were it not for such possibilities in plant life, improvement of strains would be slower work than it now is. But most potato-growers are seeking net profit from their land, and very many do not have any excess of fertility. As practical men, they should see that vitality in seed is a prime requisite. The plant should come with vigor, not requiring superior fertility to give it courage to grow, but showing good hustling qualities when first it appears above ground, and ready to use to the full all the advantages that may be within reach. A vigorous plant will make a fair yield in moderate soil, and a better yield as opportunity is given it through applications of plant-food and through choice tillage.

Medium Large Seed, Best.—While a late sett of a vigorous vine, being a second in size, has the vitality of its parent vine and may give as big a yield as a larger tuber, in ordinary field culture the chances are against it. In the case of some varieties, planted in certain soils, one need not hesitate to use "seconds" from vigorous hills. Nine out of every ten of my readers will do best not to use "seconds" at all for planting. They will obtain, as a rule, finer crops from seed pieces cut from larger potatoes. Some tests will prove convincing, but a little study of the matter may be equally so. The material in the potato is intended by nature as food for the buds or sprouts until they have root systems, capable of supplying themselves from the store of plant food in the soil. A large piece of potato will feed an "eye" and push its growth more effectively than a small piece. There are small whole tubers that will send up only one or two

sprouts. These belong to certain varieties, or else were produced from vines that never matured. These tubers have sufficient nourishment for the one or two sprouts sent above ground, and make desirable seed. But most "seconds" used in planting push several buds, whether planted whole or cut into halves. They have more sprouts than they can feed vigorously. More than this, the number of plants in the hill is too great for the fertility of the soil. The soil of garden strength and tilth may take care of this excessive number of plants per acre, and push growth so that a fair proportion of the numerous setts will attain a good size. Some nearly maximum yields have been obtained in this way. But success was due not to the seed but the soil that was equal to the emergency. For the ordinary soil and season, the number of plants per acre should be limited by the use of seed pieces having a smaller number of eyes than do "seconds," whole or in halves.

Form of Seed.—The form of the tuber is modified by the soil and season. A crop of ill-shapen potatoes may be gotten from choice seed because the ground was hard and interfered with symmetrical development, or because the season caused growth to be checked and then to be resumed after a portion of the tuber had begun to mature. It follows that results from selection for form are not as satisfactory as those gotten from similar selection in the corn field.

But one should select a variety whose type is pleasing, and then select seed fairly true to type. This is entirely practical for a grower on a small scale, but in commercial growing there are obstacles. The season or soil may have affected form temporarily, or the potatoes brought from a northern point for growing may be too costly to permit culling for conformity to type. I find it profitable always to select for vigor, and there selection must end with many growers. By selection for vigor is meant the discarding of all tubers whose appearance does not warrant faith in their ability to make strong plants. The drawn appearance of the bud at the so-called stem or butt end of the tuber, the presence of weak buds just starting, or of little potatoes in the bud, the tendency in a round or semi-round variety to form a point at the tip end with undue number of eyes, a hard, brittle texture that causes the cutting-knife to work with difficulty, dark streaks or blotches under the skin—any one of these characteristics should condemn a tuber for planting. When a man plants one hundred acres or only one acre, it is impossible that he can afford not to exercise the care necessary to secure a stand of strong plants. Some large growers assume that such care is out of the question. They are planting extensively in rich soil and get good yields. While such is the case, they are not getting the yields they should secure so long as some hills are failures because they would not discard a worthless piece of seed and supply a vigorous piece. Every piece of worthless seed represents a failure

to get a hill of marketable tubers. The man who is so rushed by work that he plants a piece of worthless seed knowingly because he does not have time to discard it when cutting, or before, is planting too extensively for best net profit. If the value of a good hill of potatoes, when produced, is not equal to the cost of throwing out worthless tubers before planting, there is no money in the crop. Each seed piece represents a success or failure for a certain area of soil. The yields of fields are kept low largely by the failure of many hills to do a fair share of the work of production. Many hills in a field usually produce at a rate that would seem extraordinary to a grower, while vacant hills and spindling vines in others, reduce the average to a moderate yield per acre. When potatoes are drilled eighteen inches apart in rows thirty-four inches apart, there are over 10,000 hills per acre. A single potato in each hill weighing a pound, would give 166 bushels per acre. I am entirely aware of the misleading character of estimates based upon single hills or very limited areas, and equally am I aware of the practical impossibility of making each hill do its fair share, but such estimates as the foregoing have shown me the folly of using a seed piece that I knew could not make a vigorous vine. Often we do not know; the impaired vitality cannot be detected. Hence a degree of failure no matter how successful the crop. But it is indefensible carelessness to use any seed that does not appear vigorous.

The tubers that make abnormal development are not the safest seed. The buds often start weak. Experience teaches that it is wise to select tubers of medium size, unwasted by sprouting in storage, smooth as type will justify, and free from evidence of disease and degeneracy.

Southern Second-Crop Seed.—Twenty years ago the market for the potatoes of the producing sections along the Ohio river was found in the south. This was equally true for a portion of the New England crop, which was quoted in the market reports as "Boston Peerless." These potatoes were sold chiefly for planting, the south being dependent upon the north for seed, and when we rolled the barrels out upon the New Orleans levee after storage for many weeks in our flatboats, the sprouted, wilted condition of the potatoes made them present a sorry sight, but nothing better was available for our customers. In time the demand fell off, and we learned that the planters were using a later home-grown crop of the preceding year for spring planting. This was the so-called second-crop seed. Concerning this seed, Professor Massey, formerly of the North Carolina Station, says:

"About twenty-five years ago, by reason of an early and favorable spring, in northern Maryland, our early crop matured much earlier than usual. Many cullings were left in the ground, which we had intended to prepare for celery. But before we

had an opportunity to do anything with it, we found so many volunteer potatoes coming that we concluded to let them grow. The weeds were pulled and chopped out by hand, and in November we dug a fine crop of potatoes from these broadcast volunteers. We wrote to friends in southeast Virginia that there they could do this thing regularly, and from that time the growing of the second crop from seed of the first crop took its rise. Of late, parties about Louisville, Kentucky, have been claiming that the practice originated there, but we are not disposed to yield the claim to the origination of the idea. * * * * Our practice is to take the potatoes as soon as dug in June, clip off a thin shaving from the seed end, and then spread them in a single layer in any convenient place and cover them about an inch over the top with soil. The land is prepared for the late crop by running deep furrows, going twice in a furrow and cleaning it out. Then at any time, last of July and early August, as the bedded potatoes start sprouts, we plant the sprouted ones (and no others) without any further cutting, and cover very shallowly in the deep furrows. Planting continues until the middle of August, though, in some seasons, those that sprout later will make a crop, but the middle of August is usually as late as is safe. As the potatoes make green tops, the soil is worked into the furrows, until, finally, all is level. The cultivation is as level as possible, the object being to conserve moisture. If covered in full in the deep furrow at once, few of them would grow, but by gradually filling, we get the roots well down in the moist earth and then cultivate flat to keep all moisture there. The importance of this crop as a seed crop cannot be over-estimated. They are gradually making their way northward for spring planting, and as all who have tried them find the crop better and earlier than from the northern seed, market gardeners will be compelled to use them if they are to compete with their neighbors who do. In our own experiments here, we used second-crop seed raised from potatoes from New York and Maine, planted alongside of potatoes brought the second spring from the same stocks. The growth from the home raised seed was much more robust than from the northern seed, and when the potatoes were dug there was not a potato in the crop from the northern seed that would not have been classed as a culling in the crop from our home-grown seed. The late southern crop of potatoes, dug last of November or first of December, have not started a sprout when planting time comes here in February, and kept in a cool, dark cellar they will not start a sprout until after planting time north. They thus start with the full, strong growth of the terminal bud, and make a strong, erect main stem; while the northern potatoes, lying many months in cellar, have to have the sprouts rubbed off, and their

growth when planted comes from a cluster of lateral buds and from a partly-exhausted food supply in the potato. The late southern grown crop is the coming seed crop for all parts of the country."

I began using this seed for northern planting about ten years ago, and find it fully equal to the best northern seed. It is preferable for early planting when small in size, as no cutting is required and a single stalk, as a rule, is sent above ground by the tuber. This insures vigor, limits the number of setts in the hill, and gives marketable size to the crop at the earliest possible date. When the second-crop tubers are small, as is the case when the planting is very late and frost arrests growth, a less number of bushels is required for planting an acre. New Jersey now grows an extensive second-crop, and my own planting of five acres this year with such second-crop Early Fortune seed was so satisfactory that there is inclination to emphasize the desirability of more extended use of the second-crop for northern planting. It is not urged, however, for the simple reason that there has been disappointment from receiving stock not true to name. This seed is wanted for an early market crop, and our growers have paid the usual high price, and given this seed the choicest early ground, only to find that the variety was a late one and unsuited to our conditions. Personally it has been found best to buy of an acquaintance among producers of this seed, and it is entirely hazardous to depend upon the representations of middlemen unknown to the buyer. At the Ohio Station the southern seed was not found superior to choice cold-storage seed of the north, but it is superior to the seed ordinarily used because it does not sprout and waste before spring, as is the case with northern potatoes in the southern portion of our potato belt.

Commendation of this southern seed may appear inconsistent with what has been said under another head, but it is not so. The small size is not objectionable for the reason that it is due not to lack of vitality but to arrest of growth by close of the season for growth, and for the reason that the small tuber, or the cut piece, does not put forth several sprouts, as is so commonly the habit of northern "seconds." So far as my observation goes, a single sprout from a seed piece is the rule, though two sprouts may not be unusual with some varieties. In respect to latitude, the second crop is grown so late in the season that the vines have as much vigor as northern potatoes growing in mid-summer. It is produced in cool weather. There is temptation to the southern producer to plant too early for sake of increased yield, and some years the tubers become very large and are matured. Such potatoes are less desirable for planting.

Immature Seed.—This second-crop potato, is, of course, immature when growth is stopped by frost. It is an old teaching that the use of immature seed is inadvisable. That able authority, Mr. E. S. Carman, has said: "All analogies point to the conclusions that immature

tubers as well as immature cuttings of any kind, will produce comparatively feeble plants. This is well exemplified by the weakened constitution of grape-vines grown from green wood." I am not in a position to affirm that continued use of immature seed will not diminish virility in the long run, and I have observed in New Jersey that the growers prefer Maine-grown stock for the first crop, from which seed is gotten for the mid-summer planting of the second crop. But it is an established fact that immature seed is desirable for a single planting. It does not evidence any lack in virility, and gives a better plant than matured seed as usually kept in our warm latitudes, because it has not lost by sprouting. The material in the cells that feed the eyes has not been broken down ready for starting a sprout before the desired time for use. So true is this that many northern growers of early-planted potatoes are learning to plant a strip very late so that the crop will hardly mature by frost, and to use this crop for the next season's planting.

Sprouted Seed.—Too much cannot be said against the use of badly sprouted seed potatoes. The material in the cells at the eyes gives a stronger bud than a second supply of material can give when the first bud is removed. The potato should be kept so cool that no buds will start until wanted. The keeping of seed will be discussed under another head. In the event that sprouts do start too early, they should be removed, and the seed should be budded in the light before planting. There is distinct loss when seed is permitted to waste by sprouting in bulk.

The Cutting.—There has been conflict in the teaching regarding the size to which the seed piece should be cut. Careful study of the results obtained at Experiment Stations and upon farms of commercial growers will show that results under like conditions do not conflict, and that a safe rule may be gotten for our guidance. For soils of average fertility and state of tilth, the larger the seed piece, the more vigorous the young plants, and the fewer the plants, the larger the tubers produced. It has been quite definitely demonstrated that a greater yield in case of most varieties can be gotten from a whole large potato used in planting a hill than from any less quantity of seed, but the increase may not be gotten with profit on account of the cost of the seed and the average size of the tubers grown. With most varieties the whole tuber will give more plants in the hill, and more setts, than is desirable. The proportion of small potatoes in the crop is made unduly large. The vigor of the vines may carry a sufficient number of the tubers to merchantable size to make the marketable crop equal to, or in excess of, the yield from a smaller amount of seed, but this is rarely done with profit. The concensus of the best opinions of experimenters is that whole, large tubers should not be used in planting.

The other extreme has been the planting of pieces cut to a single eye. Good results have been obtained from such planting. Reverting to our rule laid down, the number of plants in the hill is kept small, favoring quality in the product of the hill. But for the single-eye cutting, when quite small, we must have the same soil conditions that we have found to give a good yield from seed of somewhat impaired vigor—one that is very rich in available plant food and that is in a fine state of cultivation. The small cutting does not contain much material for forcing growth, and the plant is quickly dependent upon the soil. If conditions are not highly favorable to the plant, there will be a smaller yield than would be gotten from more liberal seeding. The advantages are, reduced setting, which ordinarly is too free when plants are numerous, and reduced cost of seeding. There have been so many grievous disappointments from the use of single-eye cuttings in soil unfitted for such seeding that I recommend such only to the grower providing garden conditions, and even then only in case of certain varieties whose great fault is free setting of tubers.

The Middle Ground.—Basing the conclusion upon many years personal experience and upon the experience of many at Stations and upon farms, the safe course for the average grower of potatoes, planted in the spring, is to use a seed piece of good size, such as will ordinarily contain two strong buds. I regard the size of the seed piece rather than the number of eyes. If there be sufficient nourishment, a single eye, being a compound bud, may send out two sprouts: if there be three eyes on the seed piece and insufficient nourishment for three sprouts, it is very often the case that only two will be sent to the surface of the ground. A piece of potato of this size does not dry out as quickly as a smaller one, pushes growth more surely, and is not unduly expensive.

As has been said, much depends upon the variety and its habit of setting, and even more depends upon the tilth and strength of the soil. Good judgment is a decided acquisition in potato-growing, coming into profitable use at every step. Our endeavor only is to indicate the nature of the plant we grow, and the probabilities, based upon average conditions. As conditions vary, there must be variation in method to meet them.

Machines for cutting are used with satisfaction by many growers. My individual preference for the hand-knife is due to the greater degree of carefulness that can be exercised when cutting by hand. Bad tubers are more surely discovered, and there is adjustment of size according to position of the buds so that no piece is left without a bud.

Much has been written about the cells that lead to the buds, and the advisability of cutting each piece in such a way that the branch cells from the central one are not disturbed. This is done by hold-

ing the tuber in such position that the butt end is down, and starting the blade slightly above the eye and cutting downward toward the center and butt end. The eyes of the potato are terminal buds of unseen "branches," and the aim of this method of cutting is to divide the potato without cutting a "branch" off near its bud. For single eye-cutting, the system works well with most varieties, and fairly well when cuttings are larger. There is no clear demonstration that yield is favorably affected. Probably as good a rule is to seek compactness in form of the seed piece.

Impotent Eyes.—In some varieties there is a tendency to form dormant eyes near the butt end, and this inclination is greater some seasons than others. The eyes nearest the butt end start more slowly than those near the tip end usually, and in many varieties the most vigorous sprouts are well confined to the two-thirds of the tuber having the tip end. In such cases regard should be paid to this fact in cutting, preferring that an eye from the middle of the tuber be joined with one near the butt end rather than that the piece be so shaped that it contain eyes from butt end alone. Where a tuber affords only four pieces, the old-fashioned method of quartering through the tip end is as good as any, if not better; but for large, long tubers I prefer clipping pieces off the butt end, if eyes are all right, until a size for four pieces is left, when it is quartered.

Clipping the Tip.—It is a common experiment with growers to clip the tip end off "seconds," the thought being that the eyes there are too numerous for proper nourishment of the sprouts. But Station experiments do not justify such cutting, showing no increase in yield. These eyes are often the earliest ones. It is very often the case that only one or two of them sends a sprout above ground, appropriating the strength of the seed piece. I prefer any eye that has been produced near this end of the potato to one produced equally near the other end. It is more sure to give a good account of itself.

Budding in Light.—The practice of starting the buds, or eyes, in the light before planting was introduced to secure earliness of crop for market or home use. Having had no extensive experience with this method, I quote the following description given in Bulletin 36 of the Rhode Island Station:

"The most desirable seed tubers for budding are those about the size of hen's eggs, sound and not mutilated in digging. They may be reserved for the purpose when digging the previous crop, and if allowed to become 'greened' by exposure to sunlight so much the better, or they may be selected from the bin at any time. During stormy days or at any convenient time during the winter these seed tubers can be placed in the trays and then stacked up anywhere in the cellar secure from rats and frost until wanted. The tray to be filled is placed upon a table or bench and one end elevated about a foot by placing a box or measure under

it. Then beginning at the lower side the potatoes selected as above are packed into the rack stem end down as closely as possible one layer deep. Tubers cut or pierced by the tines of a potato digger or fork should not be used, as they are likely to produce sickly or inferior buds.

"About six or eight weeks before planting time the rack should be placed in a warm and light place where there is no danger of frost or damage from rats or mice, and the trays placed in the rack. If the temperature is moderate—sixty degrees to seventy-five degrees—and a fair amount of light reaches all parts of each tray no further attention is necessary; they do not require watering. After a few days tiny white points will be seen at the 'eyes' of the tubers, and a few days later it will be noticed that one and often two buds on each tuber will have made more growth than the others. These buds are far different from the white, watery 'sprouts' of potatoes kept in a dark cellar. They are thick, firm and tough. If conditions are right, at the end of six weeks they will be from half an inch to an inch in length, and one-fourth to three-eighths of an inch in diameter, with many rudimentary roots at the base waiting for the moment when contact with mother earth shall enable them to burst forth and go about their work of gathering plant food. At the top of the bud are tiny rudimentary leaves also waiting to do their appointed work as soon as opportunity is offered. It is well to look at the trays each day, as, if the rack stands against a wall, it may be found that the buds at the back side of some of the trays where there is insufficient light have a tendency to grow long and white. In that case move the rack out from the wall and change the trays about so as to reverse their position. In such a case more light is what is required. If the buds are not developing rapidly enough give more heat, and if growing too fast or storms and frosts prolong the planting season beyond the usual time, give less or no heat and plenty of light. When budded ready for planting, they may be held without injury for days or even weeks by keeping the racks in a cool, light place.

"The preparation of the soil does not differ from the course usually followed in growing early potatoes. It should be deeply plowed, made mellow and filled with soluble plant food. For marking out the field, a small plow or some implement making an open furrow about six inches deep should be used. Some fertilizer should be thoroughly mixed with the soil at the bottom of the furrow which process will fill it up one or two inches. We are now ready to put in the tubers. The trays should be taken from the rack and carried to the field in a spring wagon so as not to break the buds by rough jolting. At the field the most convenient way is to place a rack on a wheel-barrow and run it along between the rows. Two persons can work together at setting the tubers, one on each side

of the barrow. Each should be provided with a thin-bladed knife and when a tuber has two good buds it is divided as equally as possible without injury to the buds and the pieces immediately and carefully placed in the bottom of the furrow, the buds pointing upward. When there is only a single well-developed bud the tuber is planted whole. Earth to cover them is drawn into the furrow with a hand-hoe."

Modified Method of Budding.—The description quoted is given on account of its value to the grower of extra early potatoes, and especially for the reason that a modification of this method has value for all growers. While earliness of maturity is sought by those using trays for budding, there is a big gain in the vigor of the plants. Not only is the time between planting and harvesting shortened, but yields are increased as a result of increased vigor of the vines. This makes the matter of budding interesting to all growers. It is not feasible to expose all seed to the light in trays and then to plant by hand, but we have learned that seed may be spread over the floors of barns, sheds, etc., for ten days or more before planting with good results. It is important that the tubers be spread very thin—one-deep is best—and that light be admitted freely. The buds push quickly and are thick and vigorous. The air makes the sprouts tough so that they do not break off in planting, and any bad seed can be thrown out. Such method is becoming common in sections practicing very late planting. The seed can be kept for weeks in late spring without injury when exposed to sunlight. If placed in a dark room, or if not turned occasionally, the sprouts grow white, tender and long, and break off when handled in planting. The secret of success in budding is to keep the potato in so much light that the sprout will not push out toward it, but will rest in it developing thickness and fitting itself for strong growth when the undeveloped roots at its base are given soil and moisture. This plan is suited to the needs of the late or June-planted crop. There is yet another modification of the system of budding that is adapted to the needs of the farmer who plants his crop in early spring, and it will be described under the head of "planting."

Varieties.—A glance at the results of variety tests at the various Stations impresses the truth that financial success or failure in potato-growing may be determined by the choice of variety. Growing under even conditions, one variety gives less than one-half the number of bushels per acre yielded by another variety. The soil may be right, the culture good and the seed in first class condition, but if the variety is not right, the yield will be relatively small. The varieties of potatoes are numbered by the hundreds in this country alone. Many of them never had sufficient value to justify their in-

troduction, while some have peculiar fitness for the climatic and soil conditions of limited areas and are valueless outside of those sections. There remain a few score of varieties that were decided acquisition, when put upon the market, and of these few score it is the individual grower's business to select the one or ones most valuable to him.

How they Originate.—Most new varieties are seedlings, though a few of our valuable ones are "sports" from old varieties, their characteristics having been fixed by careful selection. Seedlings are fairly easy to produce, but probably not one variety out of ten thousand secured proves actually to be worthy of introduction. The true seed of the potato is in the seed ball. The ball is dried, the seed is removed, and should be planted in early spring in pots. Transplanting in the earth is done when the weather becomes warm, and these plants produce tubers of many shapes and colors. Selection of the most promising ones is made, and each one should be planted by itself. If the crop from any one again gives promise of value, it is made the basis of a new variety whose characteristics are fixed by selection of tubers true to the type. Years are required to fix characteristics, and finally, when tested by the side of an old variety, it may prove inferior. It has cost time and money, and the temptation is to push it upon the market with extravagant claims of merit. These facts are not given for the discouragement of beginners in the work of developing new varieties. Within bounds it is a labor to be commended to the grower who has a little leisure and some taste for such work. There is always the chance of bringing into existence something of decided value that not only will add substantially to the wealth of the country, but also will make a good cash return to the introducer. It is a safe guess that varieties will be found in the future whose merit will exceed anything we have, and the men who produce them will serve the people as well as themselves individually. But the chances of failure are mentioned that we may be slow to invest in every novelty that is placed before the public. New varieties that are decided acquisitions, possessing a merit in higher degree than any other, are added very slowly to the list of safe varieties for planting.

How to Test.—There is a very general disposition on the part of farmers to give an extra chance to a new and costly variety they purpose testing. If the purpose is to find something of extra merit to take the place of a variety in use, the place to test is in the field under field conditions. If it cannot show superiority in a row side by side with the variety that is furnishing the income from the crop, it is a poor investment. It should have the same tillage, fertilization and, shall I say neglect, that are given to the general crop. If it then show superiority, it is worthy of another trial to indicate its action under other seasonal conditions. Rigid tests are the only ones

worthy of practical men who propose to use the results in deciding whether their chance of net profit from commercial potato-growing shall be placed in the keeping of a new variety or left to rest upon old varieties. The seed-grower has a different view-point. He is catering to the public demand, and when he believes that a new variety of potatoes is to receive a lot of booming from its introducer, it is his business to secure the most bushels possible from his limited and costly stock of seed in order that he may supply the calls upon him for this variety. It is given the best ground available, and no pains are spared.

Selecting Variety.—The grower should know his market and be governed in selection of varieties accordingly. City markets differ in their requirements. One will demand a long, white potato, and the demand is traceable to its liking for some old variety of that type which quite possibly has ceased to be produced. More productive, and usually less palatable, varieties of similar form have taken its place, and are sold by dealers under the old, well known name that is used by most consumers when ordering. Another city market demands a round potato for like reason. It does not pay a grower to try to educate a city market, and he does well to plant a variety of the general type in demand. In smaller markets the grower who disposes of his crop from his wagon, and has a regular custom, can introduce a new type of potato of superior merit with profit. Conditions determine what should be planted, and money has been lost by failure to study market requirements. Color is even more important than shape. It is a waste of time to attempt to convince a city market of the choice quality of a blue potato, however meritorious, when the people are accustomed to the sight of white or slightly pink varieties.

Limiting Demand.—The amount of potatoes consumed by the people is limited by the quality. Unfortunately many of the most prolific varieties are not high in table quality, and some of the most productive potato soils give tubers of poor flavor. The grower is mindful of net profit for the season, and plants the variety that promises the greatest return per acre. For this he is not to be condemned, but it results that millions of bushels of potatoes go on the market every season, limiting demand by reason of their poor edible quality. The consumer cannot discriminate when buying, and those who are unforunate in selection do not consume the amount they otherwise would use.

Some varieties are good keepers, and improve in quality as spring approaches. On the other hand, some of the choicest varieties deteriorate in quality rapidly by spring. Soils affect quality, and a "soggy" variety in one soil may be of high quality in another. Twenty-five years ago the Peerless was a watery potato with us, and yet

it was grown by the tens of thousands of bushels in our valley because it was the one variety most salable in our market—New Orleans—which was a depot for shipment of seed potatoes to the Gulf planters. The crop grown from the Peerless in the south suited the market, and our business was to supply the potatoes for planting, and to grow the variety wanted, adding a quarter of an acre of a more palatable variety for home use. There is a limited demand for a soggy potato from restaurants and hotels who want it for slicing. But a dry potato, bursting its jacket when boiled, and having a high flavor, is the one that helps to increase the popular demand for this vegetable.

Effect of Soil and Season.—Just as the prolificacy of a variety cannot be determined by a single test, so is a single season's test of table quality indecisive. Varieties vary with the season and soil. The highest quality in any variety is gotten in a year of rapid and constant growth. A check to growth from drouth, followed by renewed growth, usually causes a part of the tuber to develop while the remainder continues to harden its skin and mature. The new material is deposited in the tip end, destroying the typical proportions of the variety, or is formed into knobs and prongs that are unsightly. If the season of new growth is prolonged, the old material in the tuber becomes soggy and strong. Some varieties stand drouth much better than others, waiting for the rains, and remaining smooth when new growth is added.

The soil affects quality most materially. Heavy, wet land can not give us a good eating potato. We have in this country some acid soils that are full of vegetable matter, and produce immense crops of potatoes whose skin is exceptionally smooth and clear of disease as a result of the acidity, and yet whose table quality is very poor. For home use and for a discriminating market, a loose, well-drained soil, well-filled with humus for the retention of moisture, will give good quality.

Disposition to Form Setts.—In my own experience a serious fault of many varieties is the habit of too free setting. The grower too frequently is inclined to regard the number of potatoes in a hill rather than the size. The market demands good size, and a rather big percentage of buyers are influenced in their choice by this quality. Only in exceptional cases are the largest tubers the most desirable. They cannot be cooked whole as perfectly as smaller ones, and often they are hollow or hard in the center. The best flavor of a potato is gotten only when it is cooked in its jacket, without a break of the skin, and when so prepared, baked or boiled, the potato of moderate size is most convenient. But the buyer does not recognize these facts, and size is the big consideration in most markets. Size is determined largely by the number of setts, and that is con-

trolled very greatly by the habit of the variety. We exercise some control through the number of eyes left on a seed piece, but even when we cut to a single eye the necessary closeness of the hills may give too many setts, and the small cutting is quite apt to give a vine lacking vitality to bring to full size all the setts it may make. Some varieties are faulty to a marked degree in this respect. Others may set too scantily. But there should be insistance upon the point that we usually have too many tubers in the hill. A little calculation will make this clear. Where we have ten thousand hills in drilled rows on an acre, and have in each hill three tubers averaging two-thirds of a pound each, we have a yield of 333 bushels per acre. In reply, the usual remark of the grower is that many hills will not have any marketable potatoes, and other hills must be large to make the average fair. If this is so ,the fault lies not with the thrifty hills, but with the failures, and it is our business to make ninety-five hills out of every hundred do their full share. I should have liked to say "every hill," but while this is entirely feasible in limited plantings, I do not, in my own experience, find it safe to expect a solid stand of thrifty plants, no matter how much reasonable care is exercised. With some lots of seed, and especially with budded seed, this may be approached so nearly that it is practically perfect, but in the usual field plantings we use some seed pieces that do not grow at all or fail for some reason to make a crop. However, it is only a fair expectation that ninety-five hills out of one hundred will make a fair yield when we use all reasonable precautions as to soil. seed, planting and tillage. With a full stand of plants, the number of setts made by a single vine should be small, and a highly desirable quality in a variety is a disinclination to set as freely as seedsmen give assurance that it will do. A point of superiority in the second-crop seed of the south is its failure to set as abundantly as ripened northern potatoes. It can push to good size all the tubers it forms, if soil and season favor, and the good yields obtained are due to the good size of the tubers rather than to an abnormal number of undersized potatoes.

Resistant Varieties.—In the selection of varieties resistance against effects of drouth, disease and insects, is one of the important considerations. A potato may be prolific and of high quality when the season is entirely favorable, and yet be one of the most worthless of varieties in an unfavorable season. The variation in resistance to drouth and to disease is marked. As soils grow older, drouth affects them more quickly, and as potatoes continue a leading crop of a locality, diseases become established. In selecting a variety for main crop I want to know that it will do relatively well in a bad season. In years of abundance the potato-grower finds prices too low for much profit, and he learns to depend upon other years for

his best income. A good half-crop in a year of general failure means more net income than a full crop when prices are dragging badly. I have grown potatoes that yielded well in a good year but failed miserably in a bad year because the variety could not stand any hot, dry weather, or because it was peculiarly subject to the blight.

We have, to-day, a large number of varieties whose habit of growth is as similar to, and whose characteristics are known to the public as widely in, the Carman potatoes, probably, as in any varieties I might name. This Carman type has a foliage that resists disease well, and the varieties stand drouth better than many others. The branches of the vine are late in making their heaviest growth, and it may be for this reason that early blight does not attack them readily. So far as my observation and experience go, we have nothing better for our hot seasons and drouthy lands than the varieties whose habit of growth cause them to be classed together as a type to which I venture to give the name of Carman because the Carman No. 3 is a well known representative of the class.

Ohio Station Variety Tests.—No other Experiment Station makes as complete variety tests of the potato as does the Ohio Station. The work is in charge of Professor W. J. Green, whose high rank as a horticulturist and whose conservatism and safeness in estimating value are widely known. In Bulletin 133, he publishes some notes on varieties that are descriptive, and will prove most helpful to growers in making selections for trial. His results in bushels per acre are influenced by the soil and climatic conditions of the Station farm, and are not given here, but the characteristics of varieties noted by him will be found fairly correct for most sections of the country. For this reason space is devoted to them, selecting only those varieties that have had a test of three or more years at the Station.

"Notes on Varieties, Bulletin 133, Ohio Station.—The following notes on varieties are rather more descriptive than usual, for the reason that such descriptions will tend to help those who are about to make selections for special purposes:

In selecting a variety, one must first fix in mind an ideal of that which is needed for his particular purpose, whether for the table or for market, and often for a special market, which may require a potato of a particular shape or color. With this ideal in mind he can be much more definite in his search for the desired variety.

In these descriptions, particular characteristics are given as far as we have been able to give them, and attention is called in many cases to resemblance to other varieties. So far as adaptability of varieties to certain soils is concerned, not much help can be given, any further than to state that the soil on the Station farm is made up of considerable quantities of silt, mixed with clay, and is usually described as a clay loam. It is moderately fertile and has not been

highly enriched. It is better adapted to wheat and potatoes than to corn. The potato crop seldom fails on this soil, but large yields are not often secured.

The depth at which potatoes grow is influenced largely by the method of cultivation; thus the notes on this point would not hold true under a method differing materially from that used at the Station, which is practically level culture.

The notes given on tendency to sprout and keeping qualities of the various varieties have been made from rather limited observation, and some of them may have to be modified after further experience:

Acme.—Plants medium size, sixteen to twenty inches tall; somewhat spreading, more so than Early Ohio or Early Trumbull; medium to large leaflets, healthy; blights but little.

Tubers medium size; resembling Early Ohio in form and color, although not a uniform. The most noticeable difference in appearance between the Acme and Early Ohio is in the eyes, the eyes of the Acme being more deeply set than those of the Early Ohio; skin quite smooth; tubers grow medium depth and close together; yields about the same as the Early Ohio and ripens at about the same time. Does not sprout easily and is a good keeper.

Banner.—Plants twenty to twenty-five inches tall; slender stems, purple at base, thin foliage, dark color.

Tubers resemble Carman No. 3; potatoes grow medium in depth and quite close together. In 1899 yielded very heavily, in 1900 yielded well, in 1901, was not grown at the Station.

Bovee.—Plants twenty to twenty-four inches tall; a strong grower; large stalks, three to five in number; somewhat spreading; leaflets large, thick foliage; not much inclined to blight.

Tubers medium size; medium length; cylindrical; color white with pink markings; eyes medium size and depth. Not quite as early as Early Trumbull, Acme or Early Ohio. A prolific and profitable variety. Does not sprout badly and is a good keeper.

Carman No. 3.—Plants twenty-two to twenty-three inches tall; upright; branches grow upright and slender; foliage medium dark color; vigorous.

Tubers medium to large; short; slightly flattened; often tapering toward stem end; color white, not quite as clear as Rural New Yorker No. 2; skin smooth; eyes few and shallow; tubers grow medium in depth and close together. A good market variety, but not of the best quality. Small and unmarketable tubers very few. Some varieties give a greater total yield per acre, but few excel it in marketable product. A medium late potato. Sprouts quite easily; is a fairly good keeper, but not as good as some varieties.

Commercial.—Plants twenty-two to twenty-six inches tall; a

strong grower of upright tendency; thick heavy stems; very thrifty appearance; peculiar growth, branching out like a tree.

Tubers medium to large, very few, too small for market; form somewhat irregular; medium length; tapering toward stem end; flattened; color, light pink, nearly white; surface irregular; deeply indented at places, usually at eyes; would waste considerably in paring; skin somewhat rough; eyes small and medium to shallow, except where indented. Potatoes grow scattering in hill and medium depth. Quite prolific, but too large a per cent. off shape. Does not sprout easily. A good keeper.

Dewey.—Plants twenty to twenty-five inches tall; upright, tall slender stems, purple at base; foliage resembles Carman No. 3 in manner of growth but is a shade lighter in color. Not very much inclined to blight.

Tubers medium to large; form quite regular; short; somewhat flattened; usually tapering toward stem end; resembles Carman No. 3 in form, a little more regular perhaps; color clear white, about the same as Rural New Yorker No. 2; skin very smooth and clean; eyes few; rather large, shallow. Potatoes grow close together and medium in depth. Does not sprout quite as easily and seems to be a little better keeper than Carman No. 3. Ripens with Carman No. 3.

Early Dawn.—Plants sixteen to twenty inches tall; slender stems; large leaflets; foliage medium; dark color.

Tubers medium size; medium length; cylindrical; resembling Early Rose somewhat in form; color pink, about the same as Early Ohio; skin smooth; eyes quite large, medium depth. Potatoes grow medium in depth and close together. Does not yield as well as most early varieties. Does not sprout quickly and seems to be one of the best keepers of the early varieties.

Early Harvest.—Plants eighteen to twenty-two inches tall; upright, spreading; a strong grower; medium sized stems; medium dark color. Not very subject to blight.

Tubers medium size; 12 per cent. too small for market in crop of 1901; medium to long, slightly flattened; color white; skin smooth; eyes quite large, medium depth. A clean looking potato. One of the best early white sorts that has been given a long trial at the Station. Sprouts quite quickly but remains firm even after having sprouted somewhat.

Early Michigan.—Plants eighteen to twenty-two inches tall; spreading; large leaflets; dark colored foliage; stems medium size.

Tubers medium to large; medium length; flattened; oval; color white; skin quite smooth; russeted somewhat, giving a brownish appearance; eyes small, shallow; a good many small potatoes in 1901; 15 per cent. unmarketable. Does not run as large nor as even

as some; quality good. Total yield about the same as Early Harvest. Sprouts quite quickly but keeps fairly well.

Early Ohio.—Plants twenty to twenty-four inches tall; an upright, spreading grower; large stems, medium sized leaflets.

Tubers medium size; medium, rather short, cylindrical, run quite even; color pink; skin quite smooth but not as smooth as Early Fortune or Early Norwood; eyes medium size, quite shallow, rather conspicuous. Potatoes grow quite close together and medium in depth. This is still the standard early variety. Does not sprout quickly and keeps as well as any early variety.

Early Thoroughbred.—Plants twenty-two to twenty-six inches tall; spreading, covering a good deal of ground; medium sized leaflets, dark color; not much inclined to blight.

Tubers medium size; form variable, quite long, some taper toward one end and some toward the other and some toward both ends, flattened; color dark pink, much like Early Norwood; skin inclined to be rough over a part of the surface; eyes medium size, shallow. A good early variety. Possibly an improvement upon Early Rose. Sprouts quite quickly. A fairly good keeper.

Early Trumbull.—Plants eighteen to twenty-two inches tall; quite spreading vines, thrifty; foliage thick, medium dark color.

Tubers medium to large; form variable, some medium length, some quite short; slightly flattened, a little irregular; color white; skin usually smooth, sometimes roughened; eyes small, shallow, inconspicuous. Has proven to be one of the best early sorts tested here, yielding ahead of most early varieties. Sprouts quite quickly. Keeps about the same as Early Thoroughbred.

Early White Ohio.—Plants sixteen to twenty-two inches tall; a medium sized grower, with upright tendency; does not spread much; slender stem; medium to large leaflets; foliage medium density; light color.

Tubers medium to large; medium length; some quite short, slightly flattened; a little irregular; color white; skin inclined to be rough over about half of the surface; eyes medium size, shallow. Appears not to be very prolific. Sprouts quite quickly. Keeps fairly well but not as well as most other Ohio sorts.

Enormous.—Plants twenty to twenty-two inches tall; rather tall, spreading variety; large stems; large leaflets; foliage medium in density; light in color.

Tubers large to very large; rather long; slightly flattened; often irregular; color white; skin inclined to be rough on many specimens; eyes variable in depth, but mostly shallow and inconspicuous. A heavy yielder and a good market variety but of rather poor quality. This variety has not given satisfactory yields generally, but has near-

ly always done well at the Station. A medium late variety. Sprouts quite quickly but not very badly. A good keeper.

Extra Early Pioneer.—Plants sixteen to twenty-two inches tall; a strong growing, rather large plant; medium sized stems and leaflets; very little tendency to blight.

Tubers medium to large, few too small for market; mostly long, slightly flattened, some oval, tapering toward stem end; color pink, lighter than Early Ohio, about the same as Baker's Extra Early; skin inclined to be rough on some, usually smooth; eyes medium to large, shallow. Gives about an average yield for an early sort. Sprouts quickly.

Gem of Aroostook.—Plants twenty to twenty-four inches tall; thick stems, upright, somewhat spreading; medium dark colored, thick foliage; blights some but not badly.

Tubers medium to large; medium length; flattened; color white; skin very smooth; eyes numerous, medium size, shallow. Appears to be promising as a midseason variety. Does not sprout very badly. Apparently a good keeper.

Green Bay Triumph.—Plants twenty to twenty-four inches tall; a medium tall, spreading grower, with large stalks and leaflets; foliage light color; quite inclined to blight.

Tubers small to medium; very short, length often less than diameter; roundish, usually slightly flattened; color yellowish white with pink tint to eyes; skin fairly smooth; eyes medium size, shallow. Yields about the same as Early Ohio. Does not sprout badly. A good keeper.

Irish Queen.—Plants eighteen to twenty-two inches tall; a strong, compact grower, not very spreading, upright, large leaflets, thrifty.

Tubers medium size, short, a little irregular, some oval, some rounded, mostly flattened; color white, about the same as Rural New Yorker No. 2, except a slight pink tint about the eyes; skin quite smooth; eyes small, shallow, inconspicuous. Potatoes grow shallow and close together. Not a heavy yielder. Sprouts quickly, and is inclined to shrivel; not a very good keeper.

Joseph.—Plants twenty to twenty-four inches tall; spreading; stems thick; dense foliage; very little tendency to blight.

Tubers medium size; 20 per cent. too small for market in crop of 1901; medium to long, flattened, oval; color light pink, about the same as Extra Early Pioneer; skin quite smooth; eyes small, mostly shallow, some medium depth. Potatoes grow medium depth and close. A fairly good but not heavy yielder. Sprouts quickly and is not an extra good keeper.

Lakeside Champion.—Plants twenty to twenty-four inches tall; an upright spreading grower, medium sized stems, slightly irregular in row; somewhat inclined to blight.

Tubers medium size; medium to long, considerably flattened, tapering toward one end or the other; color white; skin a little rough; eyes medium size, shallow; too irregular for best appearance. Sprouts quite quickly. Not a very good keeper.

Livingston.—Plants eighteen to twenty-four inches tall; a tall, upright, spreading grower, very vigorous, thick stems; not inclined to blight.

Tubers medium to large; medium to long, uniform size nearly entire length, sometimes tapering; slightly flattened; color white, pink eyes, discolors quickly and badly on short exposure to light; skin sometimes slightly russeted; eyes small and shallow. A good yielder and cooker. Does not sprout quickly. Is very firm and a good keeper.

Pat's Choice.—Plants twenty to twenty-four inches tall; upright, spreading, very even in row; slender stems, medium thick foliage, thrifty; not inclined to blight.

Tubers medium to large; medium to long, slightly flattened, some taper toward stem end; color pink, eyes decidedly pink; skin usually smooth, some specimens quite rough; eyes few, small, shallow. A good potato, shapely, fine appearance, and of good quality. Yields about the same as Sir Walter Raleigh. Does not sprout quickly and is a good keeper.

Pingree.—Plants eighteen to twenty-two inches tall; upright, somewhat spreading, very even in row, thrifty, thick stems; not very susceptible to blight.

Tubers medium to large; medium to long, slightly flattened, of uniform diameter nearly the entire length; color white, about the same as Rural New Yorker No. 2; skin smooth; eyes medium size and medium depth. Potatoes grow shallow and quite close together. Yields about the same as Pat's Choice. Sprouts quickly but remains quite firm and is a fairly good keeper.

Sir Walter Raleigh.—Plants twenty-two to twenty-six inches tall; a tall, upright, spreading vine; large stalks, slender upright branches, resembling Carman No. 3 in manner of growth. Not much inclined to blight.

Tubers medium to large; short, thick, slightly flattened, tendency to oval, resembling Carman No. 3 very much in form; color white, but not as clear as Rural New Yorker No. 2; skin smooth, clean; eyes few, small; usually very shallow and inconspicuous. A good market sort. Sprouts quite quickly; keeps about the same as Carman No. 3.

State of Wisconsin.—Plants twenty to twenty-six inches tall; upright, dark colored leaflets, several small hills; but inclined to blight much.

Tubers medium to large; very short, some somewhat flattened,

mostly not flattened, some quite oval; color clear white, same as Rural New Yorker No. 2; skin very smooth and clean; eyes few, small, shallow, inconspicuous. A very clean looking potato. Not a very good yielder. Does not sprout badly. Has fairly good keeping qualities.

Suffolk Beauty.—Plants twenty to twenty-four inches tall; a rather tall, upright, spreading grower; large stalks and branches; very little tendency to blight.

Tubers medium to large; short to medium, thick, somewhat flattened, some quite oval; color white, although not very clearly so, seems to have a pinkish tint; skin quite smooth; eyes large, shallow to medium depth. Resembles Quick Crop somewhat. Has yielded about the same as Carman No. 3 at the Station. Sprouts very little. A good keeper.

Triumph.—Plants eighteen to twenty-four inches tall; a rank grower, spreading, large heavy stalks; very much inclined to blight.

Tubers medium size; short, rounded, quite regular; color deep pink; reddish; skin quite smooth; eyes rather deep; grows scattering and shallow. Not a good color. Very early but of poor quality.

Uncle Sam.—Plants twenty to twenty-four inches tall; upright, somewhat spreading grower; large stalks, stands up well; not much inclined to blight.

Tubers medium to large; medium to long, slightly flattened, some oval, some taper toward one end or the other; color white; skin smooth; eyes small to medium size, shallow. A fine looking potato. Quality, fair; a good yielder, and a good keeper.

Vigorosa.—Plants twenty to twenty-five inches tall; upright, spreading, large stalks, even in row, heavy foliage; very little tendency to blight.

Tubers medium to large; medium to long, mostly considerably flattened, oval, quite uniform; color white; skin quite smooth, with slight tendency to roughness on seed end. Tubers of good size, shape and appearance. Yielded as well or a little better than Sir Walter Raleigh the past three seasons at the Station. Sprouts quite quickly, a little inclined to shrivel, but a fairly good keeper.

White Beauty.—Plants twenty to twenty-eight inches tall; upright, spreading, slender stems, irregular in row; somewhat inclined to blight.

Tubers medium to large; long, nearly cylindrical, slightly flattened, mostly of uniform diameter nearly entire length, some taper slightly; color white; skin a little rough, russeted over entire surface; eyes very small, very shallow, inconspicuous. Has yielded about the same as Joseph the past three seasons. Does not sprout very quickly, and remains very firm, apparently one of the best keepers.

White Bliss Triumph.—Plants eighteen to twenty-four inches tall; upright, not very spreading, heavy stems, not much branches, large leaflets, foliage thin; not much incline to blight.

Tubers medium to large; very short and thick, diameter usually greater than length, very slight tendency to flatten; color white, very slight pink tint to eyes; eyes few, quite large, shallow; skin fairly smooth. Resembles Junior Pride of the south very closely. A fair but not heavy yielder. Does not sprout quickly. A good keeper.

White Mountain.—Plants twenty-four to thirty inches tall; upright, large stalks with long slender branches, regular in row, heavy foliage; very little tendency to blight.

Tubers medium to large; short to medium, quite thick, some slightly flattened, others not at all, some oval, some cylindrical; color white; skin has a tendency to roughness around seed end; eyes medium size, shallow to medium depth. A standard potato in some sections of the country. Has given as good or better yields than Carmen No. 3, at the Station. Does not sprout quickly. Is firm and a good keeper.

Whiton's White Mammoth.—Plants twenty-two to thirty inches tall; upright, spreading, stalks thick, foliage thick, long slender leaflets, regular in row; not much inclined to blight.

Tubers medium to large; short to medium, rather thick, not very uniform, some taper quite decidedly, flattened; color white; skin quite smooth; eyes small, medium depth. A good yielder and a reliable market sort. Sprouts quite quickly, but seems to be a good keeper."

To this list of varieties that have been given a three years' test at the Station, I desire to add one that has received a single year's test —the Early Fortune. This variety is showing value in sections devoted to the growing of early potatoes and is one of the best of which I have knowledge. Professor Green's estimate from a single year's test is as follows:

"Early Fortune.—Plants twenty to twenty-five inches tall; upright, broad spreading; a strong grower. Has very little tendency to blight.

"Tubers medium to large; medium length; slightly flattened, tapering toward stem end; color pink; a trifle lighter than Early Ohio; skin smooth; eyes medium size and depth. A clean looking potato; has a smoother, neater appearance than Early Ohio. One year's trial indicates prolificacy. Sprouts quite quickly but keeps well."

In these notes of Prof. Green, the "blight" referred to by him is not the "late" blight, as I understand it, but the "early" blight which causes premature death of vines, not attended by rot.

PLANTING POTATOES.

No arbitrary rules can be laid down safely for our government in the growing of any crop. Soil and climate are varying factors to be considered. But we can know the nature of the plant we would grow, and learn what conditions favor it, and then use those methods which, in our particular instance, will most nearly secure those conditions. We have learned that the potato likes a cool, moist soil, and we know that extreme heat is harmful. A corn plant likes heat. We learn to guage roughly the yield of corn in the United States by watching the range of the thermometer. There must be moisture for corn—moisture is the first essential in all plant growth—but moisture with absence of normal heat will not give us a good crop of corn. Great heat with normal moisture will give us a very big yield. Heat fills the cribs rapidly. This cereal being a heat-loving plant, we wait until the ground is warm before planting; we do not plant deeply but let the first roots feed at the surface, and we try to utilize the mid-summer heat for forming the ear.

But the potato, as we have seen, does not want so great a degree of heat. It thrives best in the most northern States, or on mountain ranges having the climatic conditions of more northern regions. It wants the cold that corn dislikes. In the center of the corn belt we plant that grain after the soil warms up, and yet early enough to bring the earing stage in mid-summer when there is abundance of heat. In the latitude of best corn production we have too much mid-summer heat for the potato, and we learn to do one of two things: To plant very early and get all growth possible before August, or to delay planting so late that the vines will be making their best development of tubers in September when the nights are cool. Where the planting is very early, even in case of medium varieties, a fair yield may be gotten by the first of August. If that month should be unusually cool, a maximum crop is gotten, but we count upon the time prior to that date. When the planting is late, we do not want any approach to maturity of vines until the fall brings cool weather favoring growth of tubers. For this belt nothing can be said in favor of planting at a time half-way between early and late. The vines reach a stage of growth that makes them subject to the diseases that develop in great heat, and yet have not had time for making a crop. Farther north these conditions do not prevail; the summers are cooler, and planting in May is as safe as earlier or later.

Early or Late Planting.—No one can decide whether early planting or late planting will give the best results until each is given a faithful trial. It is a matter of soil, climate and market conditions. Some localities succeed admirably with June-planted crops while other localities of the same latitude fail utterly. It is largely a ques-

tion of moisture. If land have plenty of humus, or if it be so located that autumn rains may be counted upon with some certainty, there is much in favor of growing the crop in the cool days of fall. The season of cultivation is shorter, there is better control of weeds, early blight is less to be feared, and there are fewer insect enemies. As a rule, moreover, when June-planting does succeed, the yields of these late-planted fields exceed the yields from early planting, so that decreased expense in growing is attended by increased yields.

One serious objection to late potatoes is interference with a crop rotation that is desirable in the belt of which I write. For thirty years in my own experience have I noted the advantages of a three-years' rotation of potatoes, wheat and medium red clover. Potatoes pave the way for wheat, giving a nearly perfect seed-bed, but this is possible only with the early-planted crop. I do not mean early varieties, necessarily, but medium varieties, like the Carman, planted very early, which make their crop before fall, and can be harvested before time for firming the seed-bed for fall grain. A late crop of potatoes does not get out of the way for fall seeding, and disrupts one of the best crop rotations known.

There is the additional objection, and a most serious one for the belt of which the fortieth parallel of latitude is a central line, that the crop comes into the most direct competition with the northern potatoes that are grown under the most favorable climatic conditions and can be placed upon the market more cheaply than our more southern crops. I incline to think that the best money has been made in late years by those growers who had a ripened crop ready for market before frost. The autumn frosts stop the growth in the northern fields, and there is a rush of their product upon the market that nearly invariably causes a decline in price.

The disadvantages of early planting may be great. Heavy spring rains are not infrequent, and cause some rotting of seed. They pack the soil seriously, undoing much of the work of preparing it for planting. Late frosts may cut the tops, and such damage cannot be fully repaired by the plant. The stem underground may not rot, but it sends out too many branches to take the place of the old top, and the yield is rarely, if ever, satisfactory. The potato beetles and the flea beetles time their arrivals to catch the early-planted fields at a tender stage. But in very much of the belt of country mentioned there are advantages that counterbalance all disadvantages. A chief one is the probability of a better supply of moisture in the first half of the year than in the latter half. There may be no more rainfall, but evaporation is less rapid. Indeed in this belt the area devoted to a late-planted crop is far smaller than that given to early planting, experience having demonstrated the danger of drouth in September. The time of planting is a matter to be de-

cided by the grower for his own soil and market—either quite early or quite late. He may do best to get his chief growth before August; he may do best to hold the crop back for the cool season after August. A compromise between these dates is not satisfactory in the ordinary season, for the reasons stated.

Depth of Planting.—Just as our knowledge of the nature of the potato guides us in determining the time of planting, and the correctness of our knowledge is attested by our experience, so are we guided in respect to the method. Much failure in the potato crop is due to shallow planting. It is all right to plant corn shallow—it wants the heat, and should root in the surface soil; but the seed potato should be down where the soil is cool and moist. The depth depends upon the soil. If it be loose and well-drained, a depth of four or five inches under the level of the surface when firmed with the hand is not too much. If the ground is heavy and not well drained, a less depth is better. Experience was required to convince me that I was not planting three inches deep when dropping by hand in furrows apparently five inches deep. The sides of the furrows, the pieces of turf that held the seed up from the furrow bottom, the ridge thrown over the seed—all help to deceive one concerning depth. After the planting, when the soil had been made level with the plank drag, the seed would be found not two inches below the firmed surface. This is a common mistake, and a serious one. It is true that a soil may be so heavy in texture and so wet that it is wholly unfit for the crop, and if it is planted the seed should be left very near the surface so that the plant roots may have air, and that the tubers may grow in loose soil thrown up into a ridge late in the season; but planting in such ground is too hazardous for the man who has a living to make in this world. It is better to underdrain, and thus to lower the level of soil water, and to make the soil loose by the addition of organic material; then potatoes can be planted at a good depth with chance of a fair crop almost in any season. For heavy soils, no matter how well drained, three inches of depth below the leveled and firmed surface may be sufficient; for looser soils the depth should be greater. I do not mean that the covering should be a certain depth, but that the potato should be placed at the depth mentioned below the level of the surface of the land.

The Covering.—When planting in soils at all heavy, and especially if the planting be early so that heavy rains are probable, I esteem the manner of covering the seed one of the most important points to be observed. My conviction in this matter rests first upon the improved yields secured in my fields during the five years that I have been covering the seed very shallow. A few years previous to the adoption of the present method it was realized that the potato seed should be planted at a good depth, where there was moisture and a

degree of coolness not found at the surface. Accordingly the planter was set to run to a depth of four inches, or thereabout, and the disks threw up a ridge that gave added depth for the time. This ridging of the soil over the row was an old-time practice of the community to secure control of weed growth. The ridges were left about two weeks, and then the ground was floated level, giving fresh, clean soil in rows for the potatoes that would soon appear above ground. This method of covering has much to commend it for all loose soils, and probably no better one can be devised. But I found finally that it was all wrong for a heavy soil. Rains would follow our early planting, settling the soil closely about the seed pieces, excluding all air and light. Digging down to see what stand of plants was promised, I found in every wet season that the sprouts, as they left the eyes, were too small and weak. They would increase in size as they approached the surface that had been made loose with harrow or weeder, but no plant of that sort ever makes a full yield. It was seen that good depth was needed in planting, and yet the results were not encouraging whenever heavy rains came soon afterward. If the soil had been of loose texture the results would not have been grave, but most good potato soils are inclined to heaviness, as only these can withstand drouth with much success.

The Cornell Station has done invaluable work for growers through the experiments conducted by Professor Roberts and Mr. L. A. Clinton. It has called wide attention to the value of tillage and of humus in the soil. This Station has practiced deep covering of the seed, throwing the ridge over the row and dragging it down before the plants were up to the level of the ground. Vigor of the plants caused the good results of the Cornell Station to puzzle me greatly until I visited the Station and examined the soil. It is a loose soil, two fifths being rotting gravel, and the heavy covering given to seed would not pack. In the case of such soils there can be no particular objection to deep covering. The air is not excluded and strong sprouts can be secured. But the method is not advisable for any other than porous soils.

Securing Good Buds.—Under the head of "Budding" reference was made to a modification of the original method that was feasible for the extensive planter. The plan of covering the seed deeply was as wrong in theory as it proved to be in practice. The bud on the seed piece was far from light and air when rains had sealed up the ridge of soil thrown over it by the disks of the planter. The result was that the young sprout did exactly what it does when starting in a dark corner of a cellar, or in the center of a pile—it stretched out for the light, making a spindling growth. Seed exposed to the light starts strong buds—there is no stretching toward the light because they are in it. The farmer who plants early and extensively usually

does not have time or place for exposure of seed to sunlight to get strong buds, and yet in a soil that is not very open he does wrong to place a heavy covering over it that will become close when rain saturates it.

The natural thing to do is to plant without any delay when the ground permits, to put the seed into furrows sufficiently deep to permit deep rooting, and to cover so slightly that there is a degree of exposure to the light and air. This is easily done with a planter, and less satisfactorily so by hand. I have learned that when the soil has been prepared for the seed, there is no need of any opening shovel on the planter, the shoe doing perfect work. Neither is there need of any covering disks. When the soil is fine, loose and properly dry for work, it falls back into the furrow made by the shoe after the seed piece has dropped into place. Not much falls back, but not much is wanted. At the usual depth to which the shoe should go, there is loose, moist soil to surround the seed, and such a covering is far better than the small, dry clods that form at the surface in the sunshine and are dumped upon the seed by covering disks. After five years experience in field practice I can say safely that the method works most perfectly when the soil has been properly fitted, and the outcome is an even stand of strong plants because the eyes start under so slight a covering that they may be said to be budded in the light.

It is best to attach a small section of a log to the rear of the planter by a wire, making the log drag along in the furrow over the potatoes to perfect the covering. Some seed pieces may have been left uncovered, and some have more soil fallen in upon them than is wanted, and this log—four feet long and eight inches in diameter—evens it somewhat. When the planting is finished, the field is in furrows apparently ready for hand-planting, and the seed is under the bottom of these furrows just deep enough to be covered from sight.

It may be thought that seed in this position would be unusually subject to injury by heavy rains or by drouth, but experience shows that it is otherwise. If a soil becomes saturated, the excess of moisture in the row will be held about the seed pieces for a longer time when a ridge of soil has been piled into the furrow than when it is open so that the air can dry it out. A mass of saturated soil over the potato will do more harm than an open furrow because the water will remain in it longer. I have observed closely in respect to this, and apprehend no more damage from excessive rainfall on potatoes covered very shallow in deep furrows than on potatoes planted in the common way, but rather less damage.

In drouth, this method gives good plants. A fresh-cut seed piece

should not be placed in contact with very dry soil. There are repeated instances of failure when such fresh-cut seed has been dropped by hand in old furrows whose surface was very dry. The soil becomes a sponge that absorbs the moisture from the potato. But when the shoe of the planter is run deep, as in this method of planting, the potato is slipped into the moist soil, and the covering is from the sides of the furrow made by the shoe. It is fine soil, not hardened into minute clods by exposure to the air on the surface, and unlike the covering gathered by the disks in our rather clayey fields when the planter runs less deep and all the covering is given by the disks that gather up the surface soil. The fine and moist soil about the seed piece does not dry out readily because it is below the moisture level in the middles between the rows. If the potato seed were not cut, there would be no need of any moisture. The potato would start its buds just as readily in the absence of moisture as is done when seed is budded on the barn floor. After good sprouts have been started, and roots are put forth at the base of the sprouts, moisture is needed. In my own experience there has been one year when, on account of poor physical condition of the soil, I feared that the seed was too dry after the buds had started, and having secured the strong sprouts desired, the furrows were filled at once. But the method of planting that is recommended here for rather heavy soils can be accepted as safe in any sort of a season, and especially beneficial in a wet one that would close up a heavy covering of soil and thus exclude light and air from the seed at a time when it most needs it, viz., when it is putting forth its buds.

Time of Cutting Seed.—In extensive planting the cutting of seed several days ahead of the planting cannot be advised, though some successful growers practice it. The serious objection is the danger of injury in case planting is delayed by the weather. Cut seed will heat if put in considerable bulk, and when not in bulk it is liable to dry out too much. By the use of potato boxes it may be kept in fair condition for a considerable period of time. The pieces should be dusted with plaster and the boxes should be tiered so that they can be covered with canvas to prevent the air from entering freely. In hot, windy weather a few hours exposure of cut seed spread on a floor will dry it unduly. The advantages of cutting seed considerably ahead of planting are the saving of time when the ground is ready for field work, and the decreased liability to rot in the ground if a rain should follow the planting closely.

But there always is danger of a protracted wet spell during the planting, and the risk of losing the seed, or of having it damaged, when cut and unplanted, is so great that most extensive growers are agreed upon the plan of cutting the seed as wanted by the planter. A seed piece heals no more nicely anywhere than in fresh soil. The

one danger is that of rain before there is time for healing. In my own experience this is a thing to be feared. When a shower falls upon seed planted within two or three hours, the chances are that the fresh-cut surface of the seed pieces will not heal nicely, but will begin to slough in spots, and while there may not be missing hills, the plants are not as vigorous as those from undamaged seed. Seed cut and healed ahead of planting time can withstand the water. But everything considered, as a matter of fact in experience, it seems wisest not to cut more seed ahead of the planter than can be used before bad weather interrupts the work.

In Dry Furrows.—A number of instances of a poor stand of plants are directly traceable to exposure of fresh cut seed in dry furrows for a short period before covering. When the sun is very hot and the furrow is dry, a piece of cut seed should not lie uncovered. In the old way of hand-dropping and covering with a plow I have left a strip of land uncovered during the noon hour when the furrows were dry and the sun was very hot, and have had a poor stand of plants on that strip, while the remainder of the field, with similar soil and seed, had good plants. Whole potatoes would have been uninjured, but the cut pieces were badly damaged.

Potato Planters.—In the case of cereals, the automatic planter does good work because the seed varies little in size and is not injured by handling. The work of automatic potato-planters is less perfect for obvious reasons. The seed pieces are uneven in size, tender and more inclined to feed irregularly. Much has been done to obviate the difficulties, but I incline to think that we ask too much of the planter. So far, at least, no machine has been devised that will make no misses when all the work is left to it, and it is profitable to depend in part upon human labor. A machine can be so constructed that it will place the great majority of the pieces where they should be, but if five per cent. of the hills are missed in planting, the loss will be considerable. The missing hills on an acre of ten thousand hills would be five hundred, and if a hill represent only one pound of potatoes, the total decrease in yield due to faulty machine work would be over eight bushels. Ten per cent. is not an unusual rate of missing among the automatic planters on the market.

It is better to make a planter that will do all that reasonably may be expected of it, and have provision for aid from an extra man or boy carried on the planter. In this way it is possible to have the work done without any misses at all, except where the seed piece is thrown in the furrow by the motion of the planter.

A planter does better work in some ways than can be secured from hand-planting. The seed is brought into a straighter line, and there is greater evenness in depth. Straight rows, or rows in which the plants do not stand zig-zag, can be cultivated more perfectly than

others. When seed is dropped into the ordinary furrow, the pieces often fall to one side or to the other of the center, and are held up by little clods or other soil that has fallen back from the sides. I should prefer to pay one dollar an acre for use of a planter rather than to have the work done by hand free of charge. But the planter must be a good one that does not miss hills in its work.

The man who plants five acres of potatoes a year should have the use of a planter. Ownership of such implements is desirable because then there need be no delay when the work should be done, though the hiring of implements may be entirely feasible in many instances. But in all this there is no desire to discourage the man who wants to plant only two or three acres a year and can not hire potato machinery. He is not greatly handicapped in his competition with larger growers. His small acreage can be given plenty of care, and can be made to yield nearly as much net profit per acre as that gotten in large fields by use of special machinery. The furrows opened to receive the seed should have a chain dragged through them to push small clods or loose soil to either side, straightening the line in which the pieces fall. The covering should be moist soil if the seed is fresh cut. The seed should be cut with such care that all bad pieces are discarded. In these ways the prospect for a crop may be made even better on a small plat than that of a large field where there is constant temptation to rush the work at the expense of future results.

There is an old custom of putting two seed pieces into each hill. It has its advantage in case of the use of untrustworthy potatoes for planting, as there is the chance that if one piece does not send up a good plant, the other piece, cut probably from another tuber, may give a good plant, and the hill is not a total failure. But when care is taken to have good seed, nothing is gained by cutting fine and using two pieces in a hill, while there is loss from unnecessary exposure of cut surface to the soil, be it wet or dry. When a lot of seed is good enough to be used, there is loss and no gain from such fine cutting that two seed pieces are required in a hill.

Distance Between Hills.—The width between rows is governed by the habit of growth of the variety. The rows should be sufficiently close to secure thorough shading of the surface when the vines have reached full growth. The shading prevents evaporation of soil moisture and helps to protect the stems from the burning rays of the sun. Thirty-six inches between rows give sufficient space for any variety, and for early varieties I prefer not more than thirty-two inches. In the drilled row the distance between hills is governed by the amount of seed used in the hill and by the variety planted. Assuming that the seed piece is a fair-sized block of potato containing two strong eyes, eighteen inches give good space for rank-growing varieties. Land may be so foul or heavy that checking is best, but in

case of ordinary soils, properly handled, drilling is to be preferred. Good tillage at the right time gives control of weeds, and the better distribution of the plants gotten by drilling favors the yield of crop.

Applying Fertilizers.—Theoretically all fertilizers should be distributed throughout the soil. The plant roots go everywhere, and the feeders are formed chiefly near the tips of the roots. When available fertility is supplied close to the base of the stalk and there only, the plant roots do not spread as rapidly throughout their whole feeding ground as they should. In a loose soil that demands no deep tillage after the potato plants are up, the fertilizer should be broadcasted and worked into the ground before planting, or else applied with a fertilizer drill. But experience with rather heavy potato soils leads one to practice some row fertilization. The tillage must be deep later in the season than is favorable to wide root growth, and there should be a full supply of plant food in the row. In such cases it may be a good plan to use the fertilizer drill as a harrow in preparing the seed bed, applying one-half of the fertilizer. The other half may be applied in the row when planting, or later if the deep furrow with light covering be used. In the case of early potatoes it is often advisable to put all the fertilizer in the row. Planters have fertilizer attachments. When the planting is done by hand, and the fertilizer is put into the furrow before the seed is dropped, it is a good plan to go over the ground with a two-horse wheel cultivator and mix the fertilizer in the furrow. With one narrow shovel on each side of the cultivator, two rows may be prepared at a time. It will be found that a trace chain, fastened to each shovel and let drag behind in the furrow, will push little clods aside and assist greatly in securing an even depth for seed and straight rows. The seed can be dropped by hand in such furrows in lines nearly as straight as those made by a planter.

But when the deep furrow with light covering is used, the fertilizer for the row may be effectively applied after the planting, and my individual preference is for this way. The potato needs no fertilizer for two weeks, or even longer, in the cold spring, because the sprout is fed by the seed piece. If there be nitrate of soda or other soluble carrier of costly nitrogen in the fertilizer, rains waste it. The available phosphoric acid, in my opinion, is most effective when first applied to the soil. There is no better time to apply such fertilizers in the row than when the sprouts are ready to come through the little soil that covers the seed pieces. It falls where some of the roots will form, and is ready to push growth. It is practicable to apply with a grain drill having a fertilizer attachment, spreading the horses with long neck-yoke and double-tree so that they have two rows between them. All holes in feed-box may be closed except the ones over the two rows. The drill should have extra large capacity, as is now provided for distribution of ground lime, and then the fer-

tilizer can be fed out in the desired quantity. All the hoes should be let down so that the ground may be cultivated, though only two or four are distributing fertilizer. On account of the deep furrows, the hoes do not disturb the setts, and the cultivation partially fills the furrows, killing weeds and adding needed covering to the potatoes.

But the grower of a few acres only may prefer to distribute the fertilizer by hand in the furrows, and the best work is done in this way. When it has been so scattered, a weeder or harrow should be used to make a partial filling of the furrows. In a few days the plants again appear, and another cultivation will complete the filling, giving clean, fresh soil in the row. Where the soil is loose, the weeder does this work well; in stiffer soils the harrow or spring-tooth wheel cultivator is more satisfactory.

In defence of the practice of applying commercial fertilizers in the row, it is a pleasure to be able to quote so good an authority as Professor E. B. Voorhees. In his book on "Fertilizers," page 217, he says: "In reference to the method of application, while very good results are secured from the application of fertilizers directly in the row, this is to some extent influenced by the character of the soil. Where the soil is somewhat heavy and the circulation of water is not perfectly free, it is less desirable than where the soils are open and porous and free circulation is not impeded; though where the amounts supplied are considerable, it is recommended that at least one-half of the fertilizer should be applied broadcast and worked into the soil, and the remainder placed in the row at the time of planting. Naturally, when the soils are poor, a concentration of the constituents is more desirable than when the surrounding soil possesses reasonably abundant supplies of available food."

CULTIVATION.

One object of cultivation is to kill weeds. In potato-growing it is essential that the ground be kept clean by destroying the weeds before they make much root. With the old method of planting shallow and ridging the covering, we got clean soil by dragging the ridge down immediately before the plants reached the surface. It was a good way of starting the potatoes ahead of the weeds. But we get the same results from leaving a furrow open over the plants and filling in as the plants grow. When they are above the level of the surface, the furrows have been filled with loose soil, and all weeds have been destroyed. It is always possible that rains may interfere with the work, and some weeds may be among the potato stalks in the unfilled furrows, but it is safe to use a wheel-cultivator, throwing plenty of soil against each side of the plants, and if some ridging is

done to secure complete burying of all weeds, the ground can be leveled with the weeder without injury to the potato tops.

Until the plants are a few inches high, cultivations with weeder or slant-tooth harrow should be given whenever weed seeds are sprouting or a crust is forming.

One Deep Working.—We now come to a cultivation of a kind that seems severe to the plants, and yet in all soils except the loosest it is essential to maximum crops. The potato makes its crop down in the soil. The physical condition of the land at time the crop is produced is more important to it than it can be to corn. The latter plant makes its crop in the air, and has all the room it wants; the potato must displace soil to get room for its tubers. A naturally loose soil will remain in good physical condition throughout the season, but such soils are rarely retentive of moisture, and the great bulk of our potatoes is grown in land that becomes too compact for the best development of tubers. With such soils the only rational thing to do is to undo the work of the rains that have fallen after the planting by making the ground loose once more. Roots will be sacrificed, but this may not be an evil. Planting early, our potatoes incline to make root growth too near the surface of the ground during the cold and wet weather usual to the month of May. These surface roots cannot be depended upon when heat and drouth come. It may be just as well that a deep cultivation is required to loosen the soil, as the destruction of these surface roots leads to deeper rooting. That is a point that does not require discussion here, the cultivation being a necessity for other reasons. It is my experience that this one deep cultivation, given when all plants are well above ground, can hardly be too close, if the soil is compact as a result of beating rains. A deep-running wheel-cultivator can be made to do fairly good work, and I hesitate to recommend any implement less modern. When it makes the soil loose in the row, where the tubers will be formed, nothing more can be desired. But very many of us are growing potatoes in heavier soil, and we are willing to give any sort of tillage that will show the most profitable results.

An Old-fashioned Way.—The point of the shovel of the cultivator should be run under the plants at this stage of growth, if the ground has settled firmly. Tubers cannot form in a hard soil. It is not now a question of root growth, but of the possibility of good physical condition of the soil in the hill. If the shovels of a wheel-cultivator, running on both sides of the plant, are pointed under the row, they will lift the plant out. A number of years ago we abandoned the use of the more modern implements for this one cultivation, and leaving them in the tool-house we returned to the use of the old-fashioned one-horse plow, having but a single stock. With a long and very narrow shovel, the plow could be held at such an angle

that the soil in the row under the plant could be shaken up. The method is slow and laborious. One man can cultivate only two and a half acres a day. But the work is rightly done, and potatoes are peculiarly responsive to right treatment. It is the soil in the row that interests the potato-grower. It should be loose naturally, if only such land were retentive of moisture. But if it were, it is not found on half the farms that should produce some potatoes. Dealing with land that compacts in heavy spring rains after the planting, we learn to make it loose in the row just as late in the period of crop growth as we dare. That time is when the plants are a few inches high. It is safe to go further and to say that if unusual weather conditions delay this work, and if the ground in the row is found very compact when the vines are even one foot high, it is better to sacrifice some root growth and make the soil loose enough for development of tubers than it is to go ahead without chance of crop. In such a case some crop may be gotten by throwing up loose soil in a ridge so that the potatoes may grow in it, but that calls for root-pruning anyway. However, it is an unfortunate condition of things that justifies such heroic treatment, and indicates failure to provide humus for the soil before planting. The only safe course is to make close land friable by drainage and by plowing down vegetable matter, and then give all deep and close tillage before the plants are many inches high.

The use of a single-shovel plow is a matter of arithmetic. If in the hands of a man who will use it faithfully and rightly it will do sufficiently better work than a more modern and rapid cultivator to pay, use it. Some growers find that it will; others think otherwise. If the soil is loose anyway, or if the workman is unwilling to hold the plow steady with point under the row, a wheel-cultivator is to be prefered.

Soil Moisture.—Professor King, in his valued book entitled "The Soil," says: "After the plant food has been prepared in the soil or in the air, it is useless until endowed with the possibilities of movement toward and through the living tissue. But water, through the action of capillarity and osmotic pressure, is the medium of transport by which the ash ingredients and the nitrogen of the soil are moved to the roots of plants, by which they are drifted into the sunshine of the laboratories in green leaves and bark, and from which they are again taken to their final place in the structure of the plant. Nor is this all, for water is itself a food substance used in large quantities by all plants of whatever sort. By its evaporation from the foliage of plants, it not only holds the temperature down within the normal range of the vital process there going on, but, because of this lowering of the temperature, it also hastens the osmotic flow of sap toward the leaves. The amount of water demanded by crops under

our methods of culture is very large." In Wisconsin, Professor King has found that 422 tons of water are required to produce one ton of dry matter in the potato.

Control of Moisture.—The first tillage in the potato field is to kill weeds and to break the crust. A single deep cultivation, close to the plants, is advisable for most soils, when all the plants are fully above ground, to insure looseness of the soil in the row. The tramping by horses and men in the middles makes a deep cultivation of the middles, with the long, narrow shovels of the wheel-cultivator, desirable. It should be given at the time of the deep working next the plants. All has now been done that can be done with cultivators to insure a crop, excepting the stirring of the surface to conserve moisture and prevent weed growth. But these surface stirrings are an important part of potato culture. Some Stations have conducted experiments to determine the number of cultivations that is best for potatoes, but a moment's consideration should show their lack of special value.

There is no certain number of times to cultivate potatoes. All depends upon the soil and season. It may pay to stir the soil twice in one week. It may not pay to stir it for ten days. When a crust is forming, or when the soil mulch is settling down solid so that moisture evidently is escaping, tillage is needed in the event of probable drouth. If abundant rain follows, the gain from the tillage can be only slight, but no one can forsee the weather conditions, and experience has demonstrated the profitableness of conserving the moisture we have in the soil.

The Source of Our Best Moisture.—Some people seem to have the impression that they should look to the clouds during the summer as the one source of moisture for growing crops. The fact is that the best source of supply of water for a summer crop is the rains of winter and early spring. I do not say that this is the chief source, but it is the best one because it is measurably within our control. The water that falls in the winter and spring, going down into the ground and coming back in time of drouth, is that with which we should most concern ourselves. It is our store at hand, and with the clouds we can not deal. The soil is a great sponge for the holding of water. When it is deeply plowed and full of humus, it drinks up the water from snows and rains, and that water passes down into the subsoil. One of the chief offices of tillage is to make soil receptive of rainfall and retentive of moisture. The water in the soil is moving all the time. When there is more of it at the surface than there is below, the water descends. This is observable immediately after a summer shower when we find that the plant roots remain unmoistened for a time, but know that the next morning will find the soil about them made darker by the moisture that has descended. On

the other hand, when the drying wind is carrying away the moisture at the surface of the field, the water below is rising to equalize conditions. As more moisture is carried away by the air, more rises to replace it, and there is constant loss of water—constant draft upon the great reservoir created by the rains of past months.

The Mulch.—It has never been easy for me to accept the statements of scientists concerning the problems arising in farming unless the everyday facts in the field appear to sustain them. Some young readers may share in this disposition to want evidence, and the control of soil moisture is so important that a few experiments are suggested.

In a dry spring, place a straw mulch about some berry plants, and leave the ground bare about others. Mulch one-half of a pansy-bed, and leave the other half bare. In a dry July, mulch a few rows of potatoes with litter, and leave a few rows untouched. Note the difference in results, bearing in mind that no more water has fallen on the mulched plats than on those left untouched. The difference in the moisture content, so apparent upon examination, is due to the arrest of evaporation of soil moisture in the mulched land, and to its escape from a soil that has no mulch and is left bare and compact.

Soil for Mulching.—It is impracticable to use any foreign material for mulching our potato fields, but we have learned that a mulch of soil may be made to serve the purpose of retaining the water in the ground. Knowing that the water tends to rise during drouth to replace that which has escaped into the air, our aim is to interpose something between the rising moisture and the hot air that would carry it away. The water rises in a compact material, but is checked by one more porous. Straw makes a good check, but experience has taught that two inches of loose soil on top of the compact portion also is a highly effective check. Its pores have been broken up by stirring so that water does not pass up through it readily, and it lies as a blanket, guarding the water from the wind and sun.

Another test may be suggested at this point with profit. After a drouth of several weeks duration, take a post-hole digger into a field that has had careful surface cultivation, and thus has had its moisture retained by the soil mulch, and dig a hole three feet deep, noting the degree of moisture found. Then go to an adjoining plat that has lain uncultivated for any reason,—pasture land, a fence-row, or preferably, a piece of bare land—and dig down three feet, if the dryness of that land will permit. Again note the degree of moisture found. If the land has been bare, there has been no draft upon it by plants which transpire great quantities of water through the leaves, as in the potato field, and yet it will be found much dryer than the field that has been properly tilled and has furnished large quantities of water to growing plants. The top soil can be made into

a mulch that does much good in a dry period, and the leading object of cultivation in the potato field, after the one deep tillage described, is the creation of this earth blanket. Do not decrease depth of cultivation gradually; do it at once. The one cultivation was to overcome the ill-effects of packing rains on a somewhat clayey soil after planting; later cultivations are merely to keep the surface stirred, and all the soil below such a mulch should be left alone for the use of plant roots. It is their feeding-ground, and they should be left undisturbed in it.

Kinds of Cultivators.—The implements required in modern tillage of the soil demand a considerable expenditure of money. It is not easy to determine the limit to profitable investment in them. Some farmers buy too many, having too little use for some implements to make the investment pay. But I think that a far greater number fail to buy as freely as they would find profitable. It is sure that planting should not be done unless good tillage can be given, and we must give that tillage as cheaply as possible. Human labor is high-priced labor, and the implement that saves time is earning in that degree its cost. Some crops may wait for cultivation without serious injury to them, but the potato is not one of these. It is a costly crop, requiring good soil and expensive seed, and its returns per acre are relatively large when a good yield for the season is gotten. There are few crops that repay care any better. Implements for rapid work pay for themselves more quickly in the potato field than they could in fields growing crops of less value per acre. It is my experience that a seeming surplus of horse-power and of tillage implements is desirable. A cultivation at the right time in a bad season may be worth a big sum, and no one should plant an acreage requiring the steady employment of all teams and cultivators. If he does, some bad weather will bring failure of a part of his crop.

For rapid cultivation after planting, and until the plants are several inches high, the weeder is an excellent tool. In loose soils it does entirely satisfactory work when used in time. The time to kill weeds is before they get above the surface, or at least before they form any roots deeper than the weeder teeth go. The time to break a crust on the surface of a field is before the crust hardens. But there are clay soils that pack and become hard after rains before the ground is dry enough for cultivation. For such land the weeder is needed to stir the soil in the row, and to level it, after the ground has been stirred by a heavier implement. It does not do satisfactory work among loose stones, but elsewhere the horse-weeder can be used with profit at certain times.

The two-horse wheel-cultivator is found on most farms. It should have narrow shovels, at least three on a side, and should be so constructed that they can run deep when desired and can be used for sur-

face work. Where only surface work is wanted, the spring-tooth is excellent. The wheel-cultivator is used until the vines fill much of the middles, and then the one-horse cultivator comes into use. The latter implement, going once in the middle, cannot do as good work as the two-horse cultivator while plants are small. It does not give the close hoeing to each hill that is necessary in good work. But when the vines shade the row and close work is no longer possible, the one-horse implement, with wheel to regulate depth, is nearly perfect. The object of all this later cultivation is to preserve moisture by keeping the surface two-inches of the soil loose, and care must be exercised that the plant roots in the moist soil below the mulch are not torn by the cultivator hoes. The thing to do is to give the potato plants a chance to use the food in the soil. The ground has been made loose as late in the season as is consistent with root growth, and our business then is to keep the moisture in that ground, and to let the plant roots use it in storing up food for themselves. Carelessness in matter of depth of late cultivating may rob a plant of much of its ability to gather food.

Laying Potatoes By.—Formerly we heard much about "laying potatoes by." This work then consisted of running a very broad single shovel through the middle, throwing the soil upon the row and ridging it. When this had been done, cultivation was at an end, because the ground was up in ridges and nothing more could be done. Nowadays, the potatoes "lay" themselves "by" when they make such a growth of vine that they do their own mulching of the field, and we cannot get a cultivator through the middles. The only time to cease tillage of potatoes is when the vines cover the ground. If the planting has been deep, in soil made properly loose by use of humus, the potatoes form under the dry soil mulch, and they do not come to the surface no matter how flat it is. When a crust is formed in the field by a rain, the right thing is to break it before it hardens, if the vines are not down upon it, preventing such work. The period of blooming has naught to do with determining the time to cease stirring the surface soil, except that one should have plants by that time so large that little more tillage can be given.

In all this we are assuming that the potato rows should not be ridged. Let us reason together. We know that the sweet potato is the opposite of the white potato in that it wants heat and not a great degree of moisture. Hence we learned to make ridges for them. The ridge increases the area of surface exposed to the hot air, and in the north that suits the heat-loving plant. The white potato wants the cold of the extreme northern States, as we know from its productiveness in such sections of our country. It needs a cool soil for its roots, and hence we learn to keep our land cool and moist by exposing no more of it to the sun's rays than is necessary—

by keeping the potato roots deep under a flat surface having an earth mulch.

But there are instances in which it is best to throw up loose earth in the row. If ground is heavy and wet, potatoes will do no good down in it. If there is reason for planting such land, it is best to put the seed near the surface, and to ridge the ground. The tubers are fed from the joints in the stem, and the extra soil banked up increases the extent of that part of the plant that puts forth the underground stems, while the looseness of the newly-made ridge lets the potatoes develop. While insisting on the profitableness of having the main body of the soil drained and loose, so that the plants can have the best conditions, I do not urge deep planting and level cultivation for ground of other character. It is better to plant shallow and to ridge when the soil is heavy and wet.

This conclusion, based upon personal experience, is substantiated by Station experiments. The Cornell Station says that "level culture is preferable to ridge or hill culture for conserving moisture. Ridges should only be used when the object is to relieve the soil of moisture, as in low, damp fields."

It may be added that ridging promotes earliness in a cold soil, and may be often desirable to the market gardener.

Level culture is at the best a relative term. We never leave ground absolutely level when cultivation stops. Some soil is worked into the row, and the tramping of horses depresses the middles. A difference of two or even three inches between the level of the middles and that of the row is very common where the aim is to practice level culture. It would be better entirely level, but the cultivation close to the plants and the one deep plowing in the middles even with the narrowest shovels make slight ridging. The nearer level the ground, the more benefit is derived from light rains. Level cultivation is the rational kind for land that is adapted to the crop, and the nearer we get our soils in prime physical condition for the crop, the less necessity there is of any root pruning, any surface planting or any ridging to furnish a covering for the tubers.

The Hand-Hoe.—It is our desire that this discussion of potato culture should fall into the hands of many persons who grow potatoes on a small scale in town lots and in home truck patches. They may not have the use of weeders, wheel-cultivators and other implements of the potato farm. For their benefit the statement is made here that while these implements do good work, and are essential to the large grower, no one implement has even been made that is superior to a hand-hoe when in the hands of a man who knows how to use it. The work may be too slow for large fields in most potato sections, labor not being available for its use; but the man who is able to give potato plants thorough hand-hoeing in the row may rest as-

sured that his tillage is as good as any that can be given. We like to boast of our progress, but no costly implement upon the market can stir the soil next to a potato plant as satisfactorily as a hoe in the hands of a skillful man. Our progress has been in speed and in reduction of expense, but not in any excellence of the cultivation over the hand-hoe for work in the row between the drilled plants. I do not recommend its use in the field on account of the cost of labor, though I have been led in recent years to give one hand-hoeing to all potatoes in clayey soil. The expense of $2.00 an acre thus incurred has appeared to be much less than the increased receipts per acre due to the extra tillage. But the matter is brought up for recommendation only to those who may lack a complete outfit of implements, and feel at a disadvantage in trying to grow only a few acres, or less, a year.

Excepting the use of the hoe to break the crust and kill weeds in the hill—work done in the field with the weeder and other cultivators—the object of a thorough working with long, narrow-bladed hoes is to loosen the ground between the plants soon after the one close, deep cultivation has been given. The blade should be made from three-sixteenths steel, eight inches long and three and one half inches wide. With a heavy eye and handle, it is not a light implement. The blade is long, so that it will easily reach across the narrow ridge left by the cultivator and down as deep as the ground should be made loose. It is narrow in order that too much soil may not be moved. Set at an angle of sixty degrees to the handle, a single stroke by side of the plant does the needed work, and two strokes complete the hoeing for the hill. A good workman will go over three-quarters of an acre a day, and in a heavy soil such a working may double the net profit from the crop.

Danger in Wet Seasons.—It is a common saying that a dry June is good for a corn crop. One reason is that dry weather at that time causes the corn plants to root deeply. When the weather is wet early in the season, potato plants form their roots too near the surface, and do not develop a system of roots sufficiently deep to serve them well when a drouth follows the wet weather. A reference to personal experience may be useful here. In 1901 we had excessive rainfall until the middle of June, and then a drouth set in so seriously that the local price of potatoes remained at ninety cents a bushel throughout the fall. Some fields of potatoes were not worth harvesting. Early in June I noticed that in one small field of six acres the roots of the potatoes were forming thickly in the surface soil in the row. In the middles one deep cultivation had let them work farther down. In the rows these roots were within a half inch of the top of the ground, seeking air during the incessant wet weather. The vines were then over one foot high, and the outlook was discouraging be-

cause drouth was most probable after so much rain, and these roots upon which the plants were depending were too near the surface to be of any service when the weather should turn dry and cultivation had ceased on account of the size of the vines. I had advocated and practiced shallow tillage when potato plants became a few inches high, but the conditions were so unusual that, as soon as the ground would permit, the long-bladed hoes were put to use breaking off the roots at the sides of the plants and opening up the soil to the air. It was radical work, and some slight wilting of the vines was observable. But so sure did it seem that a drouth would bring crop failure if deeper rooting were not gotten and loose soil provided, that the work was persisted in, and while the yield was not very large, the receipts were $118.00 per acre because fields left untouched could not make any growth when the drouth came. In this season—1902—the rains did not fail us for the early crop, but the same treatment certainly was not a detriment, as the yield in the same field is 250 bushels per acre. In the rather compact soil of this land a part of the yield is fairly attributable to the loosening of the soil, given by these hoes, that was needed to overcome the packing effect of rains. But this slow and old-fashioned way of giving tillage is commended chiefly to those who may believe they should not plant any potatoes because they can not buy all the implements of tillage.

Late Planting.—The details of early planting have been given because such planting is best in most sections of the belt for which this treatise is prepared. But the grower may find it better to get the growth after midsummer rather than before it. If this be the case, then the planting should be late enough to delay the development of tubers until early autumn. The cool nights of fall are even more favorable to potatoes than the early season of the year, provided moisture is present. If the planting is late, the culture is somewhat different. There is less danger of having a packed soil after planting and more danger of drouth. The work of preparing the ground for planting should be done thoroughly. The covering when planted may be deeper, and a close plowing under the plants is less likely to be necessary.

Thinning.—The price of "seconds" is so much less than that of the first grade that there is constant temptation to use small potatoes for planting. The small tuber is very apt to send up more stalks, giving more setts than are wanted in a hill. Some growers have tried to correct this tendency by clipping off the tip end that has so many eyes, but this has not been done with profit, as a rule. The matter has been the subject of Experiment Station tests, and it is fairly definitely settled that such clipping does not pay. Other growers have tried thinning. Theoretically this should give good results, and there are extensive growers who practice it satisfactorily to

themselves. But the evidence in its favor does not justify recommendation of the practice. The work must be done when the plants are small. It is very laborious, and there is always danger of disturbing the seed pieces or other stalks. For these reasons it is better to control the number of stalks by reducing the number of eyes planted rather than to depend upon thinning. The small potato that sends four to six stalks to the surface does not send as thrifty ones as the section of a large tuber that has the weight of the small tuber and only two eyes. The addition in cost due to the use of larger tubers is justified by the yield in most years.

Vine pruning has been tested by one Station, and no advantages were secured thereby.

INSECT FOES AND REMEDIES.

The potato has a number of serious insect foes. It is a common thing to hear growers lament that disease and insect attacks make their business hazardous, but I am sure that the progressive, energetic producer has no better friends than these so called foes. The staple crop that is easy of production affords a minimum of profit because production is heavy. The most careless can secure yields, and the supply exceeds the demand. This would be notably true of the potato if there were no enemies of the crop—insects or disease. The best products for the live farmer are those requiring the most skill and care in their production, as competition is limited by the conditions necessary to success. I do not care to assert that the foes of the potato are desirable, as they make life harder for the inefficient who must live, but clearly they do help the energetic.

As the potato crop becomes old in any section of the country, the foes to it multiply. This is true of insects, and especially so of diseases. As soils grow old and are permitted to become deficient in humus so that drouth cannot be withstood well, and as disease and insects increase, the tendency in potato production is to shift its center to newer and more remote land.

In the part of this treatise dealing with this subject, the mass of matter contributed by our Experiment Station scientists is freely drawn upon, selection being guided by personal observation and experience in the field only so far as they come to a practical grower of potatoes.

The Colorado Beetle.—Probably the best known insect attacking the potato is the Colorado beetle (*Doryphora decemlineata.*) "It was first brought to notice," says Professor Geo. C. Butz, "about the year 1856. In 1859, it was found in the potato fields of the settlers of Kansas. In 1861, it was in Iowa, and in 1862, it appeared in southwestern

Wisconsin. It crossed the Mississippi river into Illinois in 1864. It was in Michigan and Indiana in 1867, Ohio in 1868, and Pennsylvania in 1870. It moved eastward at the rate of about fifty miles a year for a number of years, but later it traveled more rapidly. It is reported to have reached the Atlantic coast about 1874, and Nova Scotia about 1882. When it reached the Atlantic coast, it had traveled 1,500 miles in sixteen years, and nearly a thousand miles more the next eight years in its march to Nova Scotia.

"These insects have great power of endurance. They will walk for great distances in search of food and, by direct experiment, they are known to have lived thirty days without food. In the spring, the beetles appear along with the first growth of potatoes, and while they devour some of the foliage of the potato plants, the damage is slight as compared with the destruction caused by the larvae of the succeeding brood. These early beetles lay their eggs upon the leaves of the potato. We may find the orange-colored eggs in masses, varying from a dozen to fifty, closely placed upon the under side of the potato leaf. It is said that a single female may lay as many as one thousand eggs in its lifetime. The eggs are sometimes found upon leaves of grass, smartweed, or other plants in the potato field. They hatch about a week later into peculiar looking hunchbacked grubs or larvae of a reddish color, with markings of black spots in double rows on each side. The larvae walk to the tenderest part of the plant and there feed very rapidly, increasing in size by successive moults until they are full grown. The length of time in the larval state is fifteen to twenty days, when they leave the plant and go into the ground a few inches below the surface and there pupate in a cell of earth. In about ten days later they emerge as perfect adults, which go in search of the plants again to lay eggs. There are from two to four annual broods in this country, varying with the latitude."

EFFECTIVE REMEDIES.

Any serious damage to a crop by this beetle is unnecessary. The only possible exceptions to this rule are when the beetles in the spring appear in vast numbers upon plants as they are coming up, and when the beetles of the second brood cross from the field of a careless farmer into one's own field.

In the first instance, resort may be had to hand-picking of the field, if reasonably small. Attempts to poison are not to be advised on account of the tenderness of the new plant foilage and the hardiness of the old beetle. The most feasible plan is to have the plants down in furrows, as they will be when the covering has been made shallow, and then to fill the furrows with loose soil. This gives the plants time for gaining more vigor, and for some scat-

tering of the beetles. When the plants appear again, if the plague of beetles continues to threaten their destruction, a ridge of soil may be thrown over the rows. It will do no injury, and when the plants emerge again a weeder should be used to level the land. By this time the thriftiness of the plants will usually put them beyond serious danger so far as the brood of old beetles is concerned.

The grower then has opportunity of mastery, and if he succeeds as thoroughly in destroying the larvae of the first brood as he should do, there will be no second brood to do injury late in the summer. The one practical method of killing the larvae or grubs—the "young bugs"—is by poisoning. The Maine Station made experiments with various insecticides and reached the conclusions that "in fighting the Colorado potato beetle no adequate substitute for arsenical poisons has yet been found." The efforts are now limited to finding cheaper or more effective compounds of arsenic than Paris green. There are many preparations upon the market, some of which are good and some are poor. A good preparation has strength, remains in suspension in water well, and is not soluble, as is white arsenic, which may burn the foliage. Where a high grade article of Paris green can be bought at a fair price, it may be safely recommended. Where there is no state inspection of this poison, the buyer should test his purchase before making application to the field. A few early-hatched grubs are sure to appear, and within a few hours the relative strength of the poison may be learned.

Arsenites in Water.—The most common way of applying arsenites is in water, four to six ounces of Paris green being used in fifty gallons of water. The former amount is sufficient for very young grubs, but the latter should be used if by any chance the grubs are half-grown when the application is made. It is a mistake to delay applying the poison until any grubs are half-grown. This is often done in the plea that all should be hatched out so that one application will serve. But when any of the grubs have reached such a stage of growth, some will not be killed by the poison. They are scattered over the vines, and find some leaves sufficiently free from poison to escape death, and these become the beetles that give us the second brood of grubs which often do much harm. More than this, the eating of the leaves checks the vigor of the plants. The arsenite should be applied when the grubs appear, and if it does not adhere to the vines until all are hatched, a second application should be made. The arsenite should be thoroughly mixed with water in a large bottle, and then emptied into the barrel.

Sprayers.—Devices for applying insecticides in liquid form are many. It is my experience that the knapsack sprayer is better adapted to gardens and small fields than to an extensive acreage, but it does good, thorough work. The spraying apparatus that covers

four rows at a time, having a nozzle for each row, I have discarded because the work done by it is not thorough enough. There may be improvements in it, but the probability is that human direction of the nozzle as it plays upon each hill will always be desirable. The barrel pump in a one-horse cart, carrying two hose and nozzles under direction of two men, secures thoroughness.

Applying Arsenites Dry.—The grower of potatoes on a small scale may not have even a knapsack sprayer, and primarily for his benefit I describe a method of applying Paris green in dry form that makes the poison more effective than it can be made in liquid form. The method will not commend itself to many extensive growers because it is relatively slow, and yet I have learned to leave in the tool-house all modern devices for applying poison to potato vines and to use this rather primitive method in large fields for the simple reason that it insures the death of all the grubs, and we no longer have any second brood late in summer to do injury.

Observation shows that the young grubs go to the buds of the plant when they leave the leaf on which they hatched. It is there that they find the tender fibre suited to their taste. A slight amount of poison kills quickly when taken at this age. It is right in the bud, and well down in it, that the poison should be placed, and there some of it should remain throughout the hatching season. These two things are secured by using a sifting can that drops the poison where wanted, and by having the poison mixed with some material that will form a paste in the first dew, and adhere to the leaves. Air-guns are more speedy, and they clean the vines of the grubs that are present in fair degree, but they do not leave a body of poison in the buds of the plant that will remain for the next lot of tiny grubs that are hatched. Several applications with air-guns or bellows are required, and these cannot be made when much air is stirring. Often the grubs make their appearance rapidly in threatening weather when there is wind and showers, and arsenites in water, or in dry form without a diluent that will stick, do not do effective work.

The Sifting Can.—The device recommended to the small grower is made of a tin fruit can, with a handle attached. Twenty or thirty small holes should be punched into the bottom of the can with an awl. Then near the top a slit two inches long should be cut in the side, and this bi-sected by another slit. Pulling the four flaps outward, the end of a handle three feet long should be thrust through at such an angle that it will be near the bottom when it strikes the opposite side of the can. A nail is driven through the tin into the end of the handle, and the points of the four flaps of tin are tacked to the wood. No cover is needed. This sifter is carried in one hand, and is jarred by a stick carried in the other hand, when the can is

held over the bud of the plant. There is no reason for coating the entire plant if the work is done at the right time.

The arsenite should be mixed with a material that becomes sticky when wet. There is nothing better than wheat flour, and a damaged or low grade lot usually can be bought for a small sum. The mixture should be strong—one pound of Paris green to sixteen pounds of flour—which is a sufficient amount for treatment of an acre of rather large vines. When the tops are small, and there are few branches, a less amount is sufficient, and an active boy can make the application to two acres in a day.

Lime is generally used as a diluent when applying arsenites in a dry form, but it is undesirable because it will not hold the poison on the vines during a rain, while flour will do so if set by a dew or mist. There are seasons in which a second treatment of this mixture becomes necessary, but they are the exception. If cold weather protracts the time of hatching, or if the rains are very heavy, one treatment may be found insufficient, but our experience is such that we expect one application, properly made, to suffice, and the expense per acre seems slight when it affords immunity from this pest for the season. The secret of success with it lies in having the mixture strong, and placing it where all the grubs go soon after hatching. It lodges in the new leaves of the stalk, and the grubs that hatch later find it and drop off unnoticed. I am commending the plan only to those who have a small acreage, knowing that most growers on an extensive scale will prefer the sprayers on account of the rapidity of the work. When the Bordeaux mixture is being applied for blight, the arsenite for the potato beetles or grubs is put into it.

The arsenite should be dissolved in a small amount of water before it is added to Bordeaux mixture. A convenient way is to use a large bottle so that the water and arsenite can be thoroughly agitated.

Parasitic Enemies of the Beetle.—There is constant increase in the enemies of the Colorado beetle, and this is in accordance with the law of nature that maintains a sort of balance in the insect world. When any one species increases out of due proportion, a natural check of some sort is usually provided. Several species of insects prey upon the eggs and upon the grubs of the beetle. In some years they are so numerous in sections of the country that no grubs can reach maturity. This was observable in the season of 1902 in my own fields, rendering any application of arsenites unnecessary. Another season these enemies of the beetle may be less numerous here, and we should not expect entire immunity from attacks of the Colorado beetle through such agencies, but it is probable that there will be increase of these insects.

The Flea Beetle.—An immense amount of injury is done to the

potato crop by the flea beetle. It is unnoticed by some growers while at work, although the effect is soon observed in a loss of dark color in the foliage and an appearance of unthriftiness. It is the insect that punctures the leaves, gnawing innumerable holes through them. Several species attack the potato, the so-called "cucumber flea beetle." (*Haltica cucumeris*) being most observed in the north. This insect is minute, and easily escapes detection by those unacquainted with its work and habits. Usually it attacks potatoes at a critical period of growth, and a close observer will soon discover the very small holes or yellow spots in the foliage indicating its presence. Many insecticides have been used with little success,and it remained for the Vermont Station to call public attention to the merit of Bordeaux mixture as a repellant. To this, Paris green should be added at the rate of six ounces to a barrel of the mixture, and the spraying must be most thorough. Arsenites alone are not effective, and the spraying with Bordeaux mixture and an arsenite will not give the desired results unless it is very thorough and persistent. Probably no other one enemy does as much to weaken the vitality and lower the yield of potato plants as these minute jumping beetles, and spraying against their attacks is urged even when the spraying is not needed to prevent blight or the Colorado beetle.

Where a grower has a very small acreage and has no equipment of sprayers, he may have partial success in repelling the flea beetle by dusting the vines with lime or tobacco dust when they are wet with dew.

A Cause of Pimply Potatoes.—In this place attention is called to a pimply condition of the potato that sometimes makes it very undesirable in market. The Station at Geneva has done good work in investigation of this trouble, and in Bulletin No. 113 it summarizes its results as follows: "The cause of the trouble known as 'pimply' potatoes has been definitely determined. Minute, slender white grubs have been found boring into the tubers, roots and root-stock of the potato during the growing season. The pupae of these grubs have been found in connection with them. The grubs and the pupae have been proven to be the early stages of the common cucumber flea beetle, a very injurious insect, the life history of which has heretofore been imperfectly known. The wound made by the boring of the grub results in the formation of a 'sliver,' but a pimple may or may not be produced, depending, probably, upon the state of growth of the tuber at the time the wound is made. The most practical method of preventing the pimply potato trouble is to protect the foliage against the attacks of flea beetles by thorough spraying with the Bordeaux mixture." Additional reason is thus afforded for fighting the flea beetle.

The Blister Beetle.—The "old-fashioned potato bug" is an old ac-

quaintance. There are four or five species of these beetles, and I know of no more disastrous enemy when they come in great numbers, because they are not easily vanquished. When Paris green is applied, it seems to have little effect. The only redeeming feature possessed by these beetles is that they do not raise their families on the plants, and we do not have the larvae, as well as the beetles, to fight, as in the case of the Colorado beetle. Many remedies have been tried. When the field is small and one does not have the fear of his neighbor before his eyes, it is entirely feasible to drive the beetles out of the patch, threshing the ground behind them with bushes, and letting them go in the general direction they were taking when they entered the patch. When found entering the side of a field, it has been recommended that straw be scattered along the edge, and the beetles be driven into it and then burned. This is a remedy that works at times, and fails utterly at other times. The only fairly satisfactory way of fighting this pest is by thorough coating of the vines with Bordeaux mixture and Paris green. The arsenite is put in on the principle that nothing should be left undone in the fight, but the effectiveness of the remedy lies chiefly in the repellant power of the mixture.

Potato Stalk-Borer (*Trichobaris trinotata*).—As potato sections grow older, there is increase of the stalk-borer which causes a premature wilting and drying of the vines. Dr. T. W. Harris records its presence at Germantown, Pa., in 1849, and says: "In many fields in the neighborhood of Germantown every stem was found to be infested by these insects, causing the premature decay of the vines and giving them the appearance of having been scalded." Dr. Halstead, of the New Jersey Station, gives, in Bulletin No. 109, the following life history: "The beetles appear in the fields early in spring, and they live well into June. They are ashen-gray, oval, with a black beak or snout, and about one-quarter inch in length. At the base of the elytra or wing-covers are three small, shining black dots, which give the insect its specific name. This beetle punctures the stem of the potato near the ground with its slender beak, and in the hole so made deposits an oval, soft, white egg. From this there hatches in a short time thereafter a small white larva with a brown head. This grows apace, eating in the center of the vine, either in the trunk or in one of the large branches, and attains its growth at any time between August first and September first. It is then from one-third to one-half of an inch in length, dirty white or a little yellowish with a yellowish-brown, horny head, and without perceptible legs. It lies in the stalk in a slightly curved or curled position and at some time about the middle of August constructs a cocoon of chips and fibres in which it changes to a white pupa, in which all the organs of the future beetle are distinctly visible. These cocoons may be in

any part of the stalk, but in small plants are usually at or near the surface of the ground, where the tissue of the vine is hardest, and the chances of retaining the form unaltered through the winter are greatest. The beetles mature in August and September, and remain in the vines all winter."

Concerning remedies, he says: "It is at once obvious that insecticides are of no use in this case, because the larva is an internal feeder; but its habit of passing the winter in the dead vines gives us complete control over it. Simply rake up and burn all the vines after the crop is gathered, and with them the entire brood of insects will also be destroyed. Besides this, war should be waged against the Jimpson weed and the horse-nettle, as otherwise a considerable number of specimens will be likely to survive. If the presence of larvae is noticed in the field, the only thing to be done is to stimulate plant growth to the utmost by the application of appropriate and readily soluble fertilizers, that the vines may be enabled to mature the crop despite the attacks of the insects."

White Grub.—The unsightly appearance of potatoes is due oftentimes to the grubs of the May beetle. Growers seek a direct remedy, believing that the application of some material to the soil should destroy them. Station and farm tests have been very thorough in this matter, and it may be stated confidently that no treatment of the soil with insecticides will be effective unless the insecticide is used at very heavy expense and in such large quantities that crops would be destroyed. It is common to read of success from applications of common salt, kainit and other materials, but the disappearance of the grubs was due not to the application given but to the fact that the time had come for transformation to beetles. A little study of the life history of the May beetle will make this fact plainer, and will enable the grower to evade loss in some degree. The beetles appear in May or early June, living on the foliage of various kinds of trees. Their eggs are deposited only among the roots of grass, and the grubs hatch in July or August. These grubs continue in the soil for two or two and a half years, when they change into a dormant form, and appear as beetles three years from time the eggs were deposited. The grubs in the first autumn of their lives are small, and the injury to crops by them is usually slight. In their second summer they are voracious feeders, and likewise in their third summer. I believe that they sometimes continue to eat until late fall the third year, not changing to dormant form until spring. It is quite common to find two broods of the May beetle in the same place, and there may be three, giving grubs of all ages and sizes. When such is the case, the ground becomes practically worthless, if each brood of beetles is large. Usually there is only one brood that is important, and this gives a chance for some evasion of their injury.

The fields under cultivation the year the beetles appear escape much infestation by grubs, and sod land broken the next spring, when the grubs are small, may be cultivated in corn without much danger. Winter plowing is recommended, and has a degree of effectiveness in a cold winter. Cold, heavy rains, during the month the beetles should appear cause the death of many.

The right thing to do in respect to white grubs is to watch for them at time of plowing the ground, and if they abound, the potato crop should be omitted. If planting is done, early varieties should be used, and the crop should be dug as soon as it is ready for marketing. It is idle to plant a crop like potatoes to be eaten by insects we can not fight effectively, and the white grub belongs to his class.

FUNGOUS DISEASES AND REMEDIES.

Probably the most serious fungous diseases of the potato are classified as blights. Throughout the potato belt of this country, but chiefly in the southern half of the main belt, the Early Blight (*Macrosporium solani*) is restricting yields enormously. In the northern half of the belt, and farther south in cold, wet seasons, the Late Blight (*Phytophthora infestans*) has caused great loss. Much confusion exists in the minds of many growers concerning the character of these blights. The Cornell Station has had unusual success in control of the blights by spraying with the Bordeaux mixture. I incorporate in this treatise its descriptions of Early Blight and Late Blight, and an account of the method employed at Cornell in making the Bordeaux mixture, reserving the privilege of some comment on one or two points in which my own experience in spraying does not accord fully with that of the Station. The quotations are made from Bulletin No. 140, and are as follows:

"Early Blight.—As the name indicates, this usually makes its appearance early in the season and upon early varieties of potatoes. Hot, dry weather favors its growth, and it is usually most severe in its attacks where the potatoes are planted on dry soils. It will, however, make its appearance when the weather is moderately cool. Whenever the potato foliage has been injured by the flea-beetles it seems to be predisposed to attacks of the early blight, the spores finding a favorable resting spot on the injured places of the leaf. Any condition or treatment which has produced a weakening of the plant causes it to be more likely to attacks of blight. Strong, healthy growing plants may be entirely free from attack, while plants which have for any reason been checked in their growth fall an easy prey to the disease. While this early blight does not cause the po-

tatoes to rot, it so injures the foliage that the growth is checked long before maturity and instead of the potatoes being full grown they are undersized and immature. It is very possible for the early blight to attack a field of potatoes and its presence never be recognized by the farmer, it being mistaken for a case of early maturity. This may be the reason the early blight fails to attract as much attention as the late blight and it no doubt does far more damage than is generally accredited to it.

"It is difficult to describe its characteristics definitely as so many variations occur, and as it frequently is confounded with the late blight, it being sometimes scarcely possible to recognize the difference without the aid of a glass. It usually makes its appearance during the latter part of June or during July and may even appear as late as August.

"The parts of the foilage first attacked are likely to be the edges of the leaves, the disease manifesting itself in several places on the same leaf, and affected area as first being circular in outline. The color of the foliage changes from a green to a russet or dark brown or even black and the edges curl as the tissue dies. A distinguishing characteristic of the early blight is the general appearance of the tissue of the leaf beyond the most seriously affected portions. Instead of retaining the green color of healthy foliage, it assumes a yellowish appearance similar to that of matured plants, this premature ripening probably being caused by the general weakening of the plant. This appearance no doubt is the cause of the general supposition that when potatoes are effected with the early blight the death of the vines is due to natural causes and is simply a case of early ripening when in reality it is premature and due to the blight

"One remedy for early blight will have been suggested by what has been said regarding the predisposing causes. It attacks plants which have been for some cause weakened or injured. Treatment, then, should begin with the preparation of the land. Deep plowing to furnish an adequate feeding ground and a reservoir for moisture, seed cut in pieces of good size, the surface soil crust broken with a harrow before plants are up and then thorough tillage and protection from both the flea-beetles and the Colorado beetles. If the plants are kept in vigorous growth, they will largely possess immunity to the early blight.

"Bordeaux mixture is the standard remedy for this as well as other fungous diseases. If it has used in early spring in combating the flea-beetles, and if when Paris green is used to kill the Colorado potato-beetles it is applied in Bordeaux mixture, there is but slight chance that the early blight will appear. The treatment in the manner above described serves a double purpose. The foliage is kept vigorous and healthy, free from attacks of the insect pests, and this

alone lessens the liability of attack by the blight as the Bordeaux mixture forms a coating of copper over the foliage thus protecting it."

"Late Blight.—This is a fungous disease which is responsible for the potato rot of the present season in New York State. Its appearance is well known and it has attracted far more attention than has the early blight. The widespread famine in Ireland in 1846, was largely due to the fact that the potato crop was destroyed by the late blight. At the present time another famine is threatening in Ireland and due to the same cause. In our own country while the disaster is not so great yet the loss this year has been enormous, and it is a loss which might have been prevented.

"This disease in an aggravated form is not difficult to recognize as it may be perceived both by its appearance and disagreeable odor which comes at first from the foliage and later from the decayed tubers.

"The fungus causing the common potato rot is an old offender. It was undoubtedly introduced into Europe with some of the early importations of the potato, and has in certain years proved so destructive that famines have resulted from the entire loss of the potato crop. Such occurences eventually lead to thorough study of the organism. As early as 1846, the fungus causing the trouble was very carefully described in an English publication, and since that time other observers have given the disease much attention. It has spread to many regions in which potatoes are extensively grown, so that both scientists and farmers are very familiar with many of its characteristics.

"The most interesting feature connected with the fungus is undoubtedly the wonderful energy which it exhibits, under favorable conditions, in the destruction of the potato plants. It sometimes spreads with such rapidity that a crop may be ruined in one or two days; and unfavorable conditions, or the total destruction of the plants, formerly appeared to be the only effectual agents in preventing or checking the spread of the dreaded disease. This rapid decay of both the foliage and tubers is perhaps the most distinctive of these characters which are commonly brought forward for the identification of the disease. It is almost invariably accompanied by a strong, disagreeable odor which is easily recognized by all who have once experienced it. When large fields have been attacked, the smell is particularly strong; it then arises entirely from the foliage, and is not produced by the tubers.

"The conditions which favor such rapid decay are, as a rule, not generally present throughout this State. The fungus makes its most rapid growth in a temperature of about seventy degrees Fahrenheit, when much moisture is present in the atmosphere. Cloudy

days, with occasional showers, and a close damp air are especially favorable to its growth; and if such periods occur during August and September, the disease may appear at any time. But, on the contrary, if the season is dry and hot the fungus is unable to develop, and little or no injury of this nature can appear. It is for this reason that the potato rot is not a regular visitor in most parts of the State, but is more generally confined to certain localities. These are found in the more northern potato districts, in the regions near the sea coast, and in some parts which have a high altitude. In such places the fungus may develop regularly every year, and the severity of the attack will be modified chiefly by abnormal atmospheric conditions.

"The manner in which the germ tube of a spore penetrates the tissues is interesting. It is now generally believed that the ends of the tube secrete a ferment which has the power of dissolving the walls of the cells comprising the outer layer of leaf tissue. 'When such an opening has been made, the small thread of the parasite passes through the outer layer, enters an intercellular space, and then rapidly extends its thread-like growth between neighboring cells, drawing its nourishment by means of minute suckers which penetrate the cell walls.' The entire destruction of the leaf may be accomplished. A stoma, or breathing pore, may also serve as a point of entrance.

"The rapidity with which the fungus advances within the leaf tissues depends very largely upon external conditions, and the appearances of the affected parts is also modified to a very considerable extent. Unfavorable conditions frequently render the identification of the parasite a different matter without the aid of a glass, but under such circumstances the disease may be fairly widespread and still cause little injury. In serious attacks, however, many characterteristic symptoms may be easily recognized.

"The following points should be noted: The diseased areas are of considerable extent, and may be started in any part of the leaf, but the edges appear to suffer more from new infection than the more central portions of the leaflets. This is probably due to the fact that in the case of rains these portions remain moist for a longer period than the center, since the water drains to the lower parts of the leaflets, and collect there in the form of drops of greater or less size. It is to be expected that under such conditions a fungus could gain an entrance more easily than in drier places. The decayed portions are inclined to droop; this is especially true in cases of rapid invasions, for at such times the parts do not dry so fast as the parasite advances. The rapid decay also prevents the edges of the leaflets from curling, although this takes place when the air becomes warm and dry.

"The distribution of colors over the affected leaf is very suggestive.

Under normal conditions, the unaffected parts retain a deep green color, while the diseased area may be yellowish-brown, dark brown or nearly black. But whatever the color, each area is sharply outlined. There is no gradual merging of one into the other, but a distinct change of color marks the progress of the disease. Occasionally another peculiarity may be noticed. If the leaves are closely examined it will be found that the green and the brown areas are not directly in contact with each other; they are separated by a narrow strip in which the green has been destroyed, and the brown has not yet appeared. It consists of a colorless or at most a very pale yellow line in which the growth of the fungus is probably very active. But during periods which are unfavorable to the development of the parasite this line cannot be discerned, and the green and brown tissues are apparently in contact. Under such circumstances the identification of the disease without the aid of the microscope is an exceedingly difficult matter. Let us suppose that the fungus has succeeded in gaining an entrance, and that it has advanced a limited distance in the leaf tissues. If at this time the weather should turn dry and hot, the development of the parasites would be checked, and the result would be the formation of a small brown spot or area, perhaps near the edge of the leaflet, and if several such spots exist the injury might be ascribed, without careful examination, to what is commonly known as the early blight fungus.

"The name 'downy mildew' has been given to the potato rot disease from the fact that there appears, under favorable circumstances, a downy or mouldy growth upon the under surface of the leaves. This is white in color and may be of considerable density. The upper surface of the foliage does not show it, but whenever this frost-like growth appears on the under side, it is almost certain that the potato rot fungus is present, especially if the other conditions mentioned above are also present. This external growth consists of spores and of the parts bearing them. The spores, or conidia, mature very quickly, and have the power of immediately propagating the fungus. They are small and light, and may be carried long distances by winds. It is largely owing to those bodies that the progress of this potato disease is so rapid. They are produced in countlessnumbers and are very energetic in attacking healthy tissue. It appears to be very probable, also, that these conidia, or summer spores, are the cause of the rotting of the tubers. After maturing upon the leaf, some fall to the ground and by means of water and other mechanical agents they are brought in contact with the tubers growing underneath the surface of the soil. Here they germinate and effect an entrance in the same manner as occurs above ground. The color of the affected tubers also changes to a brown, dry rot taking the place of the normal white color. The more slowly the tubers decay,

the less is the amount of moisture present; the contrary is also true. The decay does not take place in a uniform manner, but its progress varies in different tubers. In some it is mostly the parts near the surface that are affected, while in others the disease may advance rapidly towards the center of the tuber, causing the exterior to show a much smaller amount of disease than is actually present. The discoloration, however, generally presents a uniform appearance. Although it is by no means impossible for the mycelium to reach the tubers from the leaves by means of the stems, still it is the generally accepted opinion that infection does not take place in this manner. This belief was held many years ago, for in some of the earlier writings, recommendations may be found in which very high hilling is advocated so that the spores may be washed past the tubers and away from them, and not through the soil directly to them.

"There is still another feature of the late blight which it is well to bear in mind. The disease generally appears during August and September, although earlier and later attacks are not very rare. Coming so late in the season, all the earlier varieties are comparatively free from attack, but the latter ones are especially subject to the disease. This, however, is not necessarily due to the foliage of such varieties being more susceptible, but rather to the habits of the fungus. I have not observed that the age of the potato plants has a marked influence upon the spread of the disease; nor that the young foliage of the plants is less subject to the disease. It appears as if the parasite is able to thrive upon all potato foliage which is in a healthy condition at the time of the germination of the spores, and that old and young foliage or plants suffer practically to an equal extent. 'Acceptable evidence of a resting stage, or oosporic form of this fungus is lacking, and many believe that the fungus threads survive the winter in the partially diseased tubers.'

"The important question and the question which concerns every potato raiser is, 'Is there any practical remedy or preventive for the potato blight?' Fortunately there is, and there is no more reason now for a farmer to permit his potatoes to be destroyed by the blight than to permit them to be destroyed by the potato-beetle. The standard preventive is the Bordeaux mixture. This, if properly made and properly applied, will protect potatoes from the late blight and the consequent potato rot.

"Making the Bordeaux Mixture.—No doubt failure to secure satisfactory results from the use of Bordeaux mixture is often due to the fact that the mixture is not properly prepared. While its preparation is very simple it is possible the very simplicity has caused some to think no great care need be exercised in its preparation. This is a mistake, for the success of the application depends upon its being made properly.

The standard formula for Bordeaux mixture is:

Copper sulfate (pounds),	6
Lime (pounds),	4
Water (gallons),	45

"Potatoes will require from two to six barrels of the mixture per acre according to the size of the vines. In case a large area is to be sprayed it may be well to make up a stock solution of copper sulfate. The following directions for making up the solution may be found helpful. Into a barrel containing forty gallons of water suspend in a bag or gunny sack forty pounds of copper sulfate or blue vitriol. It is important that this be suspended near the surface as the solution has a greater specific gravity than water. If it should be put in the bottom of the barrel a saturated solution would soon be formed there, when no more of the copper would be dissolved. If the barrel be covered tightly this stock solution will keep for an indefinite length of time.

"The lime used should be fresh burned, caustic and not air-slaked. The most convenient receptacle in which to slake the lime is a somewhat shallow, long, water-tight box. To make up, say four barrels of the Bordeaux mixture, put into this box sixteen pounds of lime and add sufficient water to thoroughly slake. The lime should be kept well stirred during slaking that the water may come in contact with all parts. If it is desired to keep the lime for some days after slaking, it may be simply covered over with water so that the air will be excluded. When it is desired to use it, stir thoroughly and put one-fourth the contents of the box into a keg or other receptacle and dilute with twenty gallons of water. If more than four barrels of Bordeaux mixture are likely to be wanted, two slaking boxes would better be provided so that the lime will be ready for use when required.

"Into the barrel from which it is to be pumped, put six gallons of the contents of the barrel containing the dissolved copper sulfate. It seems hardly necessary to state that before doing this the copper sulfate solution should be thoroughly stirred. Fill the spray barrel half full of water and add the lime which has been diluted with twenty gallons of water. All of this material should be run through a sieve or strainer so that no sediment will clog the action of the pump.

"If Paris green is to be used to kill the potato 'bugs' put it in the mixture at this time, four ounces if the grubs are small, six ounces if they are half grown. A paste should be made of the Paris green by mixing it with a small amount of water before putting it in the spray barrel. Fill the barrel with water and the Bordeaux mixture is ready for use to protect potatoes from the flea-beetles, the blight and

the Colorado potato-beetles. A strong force pump is best, as then every part of the foliage can be covered by the liquid. During the operation of spraying the liquid should be frequently stirred, otherwise the ingredients will not be evenly distributed through the mixture."

Having given the Cornell suggestions, based upon success that must be rated as unusually high, I cannot serve the grower better than to couple with it the suggestions of Prof. W. J. Green, of the Ohio Station, who has given potato culture many years of scientific study. In Bulletin No. 76 he says:

"It has been our custom to make four or five applications of Bordeaux mixture to the potato tops each season, including Paris green, to destroy the 'bugs.' In some cases this course has been satisfactory, but the results have been variable. Some seasons the sprayed plants have remained alive two weeks longer than the unsprayed, and the yield was considerably increased by the treatment, but at other times the spraying was of no apparent benefit. Our experience has been duplicated by many others, and spraying for the potato blight is practiced less than formerly. Professor A. D. Selby, Botanist of the Station, suggests that the discrepancies in results may be due to a confusion of ideas regarding the cause of potato blight. Some have confounded tip burn of the leaves, in dry hot weather, with blight. Others have mistaken the effect of drought for blight. It is probable, also, that a bacterial disease, not amenable to fungicides, has been the cause of much of the trouble.

"Where fungi alone are responsible for the dying of the potato tops, repeated experiments have shown that sraying with Bordeaux mixture is beneficial. Where the bacterial disease prevails it appears that insects are largely responsible for its spread, also that the malady may be carried into the field in diseased tubers. In this case prevention consists in using sound seed and in keeping the insects in check.

"The work of the experimenters does not appear to be finished, either along the lines of investigations concerning the causes of blight, or in the discovery of the best means of preventing it, but it is not wise for potato growers to give up trying to combat it. They could deal with it more intelligently and successfully if they knew whether to spray for fungi in the form of the 'early blight' or the 'late blight' or whether to be on their guard against a bacterial disease.

"Meanwhile the only safe plan is to guard all sides. If potatoes rot in the field before digging, and continue to rot in the cellar, the disease will most likely be transmitted to the succeeding crop. If they appear to be sound on the outside but when cut across the

stem end a dark ring is seen, the disease is present, and will appear in the crop grown from them.

"Since the bacterial disease may be spread by insects it is even more essential than has been supposed, that the Colorado beetles, flea beetles and blister beetles 'old fashioned potato bugs' be kept in check. Six ounces of Paris green to a barrel of Bordeaux mixture is the best preparation for this purpose. Paris green is less harmful to the plants in combination with Bordeaux mixture than alone. The blister beetles and flea beetles are not killed by the Paris green, but the Bordeaux mixture is repellant to them, and they do far less harm where it is used than where no application is made. Where the Colorado beetles are very numerous, hand picking is advisable.

"If sound potatoes are used for seed, blights due to fungi may appear, but the same remedies apply. In that case the Bordeaux mixture is more useful than if the bacterial disease alone is present. The poison needs to be used in all cases, for not only do the 'bugs' injure the plants but make openings for the entrance of spores of fungi. It is quite probable that not enough care is usually taken to destroy insects affecting potatoes, for, as above stated, they are harmful, both directly and indirectly, and unless strong efforts are directed against them, other preventive measures are likely to fail."

Profit from Spraying.—It is safe to say that a thorough application of Bordeaux mixture should be given potato vines when the flea beetle appears, and this spraying will have an indirect influence against early blight by preserving the vigor of the plants. It may come at such a time that it will be a direct preventive of an attack of this blight for a short period of time. Then the very practical question arises from the grower's decision: Will it be profitable to continue to make thorough sprayings until growth of new foliage ceases—five or more additional sprayings? It would be pleasant if one could say definitely that such a course would pay, as we like to engage in profitable work. But experience teaches that local conditions must control one's course. If he live in the lower part of the northern potato belt he has learned to have little fear of the late blight. In one year out of five he may suffer loss from it, and in some sections the chance of loss is very remote. But early blight is a cause of loss to him nearly every year. If he plants his crop early, the vines have filled the middles before time for an attack. If he were spraying, he would have made two applications of the mixture before this date to insure coating of the foliage before any germs developed, but several more applications must follow to keep all new and old growth covered, and it is difficult to do this work without injury to the vines, and the work is costly. If the season re-

main cool, the loss in unsprayed fields would be slight. If it be very hot and showery he should not expect with confidence immunity from partial attack of early blight, no matter how well he may have sprayed. It is an open question, and the grower should be governed by his variety planted, the probable market price and his past experience.

It is my personal experience that it is feasible to depend much upon the resistance certain varieties offer to attack of early blight. We now have a few varieties that will not blight seriously until a good crop has been made. When such are planted in a rich soil, and are given the best culture, the danger of loss is reduced to a minimum. If other varieties are planted, and the planting has not been done very early, it is usually best to give the protection afforded by thorough and repeated sprayings. Where late blight threatens, spraying is to be advised. This blight, followed by rot, is a serious menace to the crop in cool latitudes. The spraying will not be found a sure preventive unless it is very thorough, and the blight may not appear at all, but there is more reason for undertaking the work in sections threatened by it than in those subject only to attacks of early blight, which is difficult to ward off.

I have no desire to detract from the importance of Bordeaux mixture as a preventive of the blights. Its use must increase as disease increases. But in seeking to state facts as they appear to be, an effort is made to keep on safe ground, not urging heavy investment of labor and money upon all growers, but only upon those who cannot evade loss by selection of soil and varieties, and who reasonably should expect frequent loss if sprayings are not given. The practice of spraying potatoes will increase because disease will grow more virulent, and there is reason for believing that thorough repeated spraying will prove itself in time to be financially profitable to most growers. One or two sprayings before the tops fill the middles is always to be advised, as more vigor is insured.

Tip-Burn.—In addition to the early and the late blight, there is an appearance of blighting of potato vines often seen that is not attributable to a fungous disease at all, but is the result of the direct heat of the sun, usually in connection with drouth. It is called tip-burn, and we take from Bulletin 49 of the Vermont Station the following description:

"The disease we term 'tip-burn' is characterized by the death of the potato leaves at their tips and margins, which portions dry, blacken and roll up or break off. This trouble has occurred quite commonly in Vermont during the dry, hot weather of mid-summer in 1894 and 1895, and as before stated, it was observed to a worse degree in Michigan and Wisconsin where the drouth was more severe. In its earlier stages the dead tissues are often quite free from inva-

sion by fungi, and even in the advanced stages the fungi present are chiefly such as live upon dead plant tissue only.

"Tip-burn is not caused by the attacks of parasitic fungi. It is rather attributable to the unfavorable conditions surrounding the plant, especially to the dry hot weather with insufficient water supply. It is aggravated by any other conditions which tend to lower the general vigor of the plant, such as insufficient food supply, and attacks of insects and the early blight fungus. This difficulty has not been observed to any serious degree upon plants until after they pass the blossoming period, and naturally begin to weaken.

"As the older leaves weaken, especially the lower leaves of the plants, the tissues of the interior of the leaf sometimes develop dead spots surrounding flea beetle punctures or other injuries. These spots soon dry and show distinct rings and bear a general resemblance to the 'ringed spots' caused by Paris green and by the early blight fungus. They may occur, however, in the absence of both these causes. Dr. Sturgis, describing these spots in his Report for 1894, attributed them to the effects of dry, hot weather. We believe this to be the correct explanation and would therefore associate them with 'tip-burn' rather than with the true 'early blight.'

"Prevention.—Effort should be made to increase and sustain the general vigor of the plant by proper selection of varieties, preparation and cultivation of the soil, and protection against the attacks of insects and fungi. The only thing that can be done in addition is to irrigate in times of extreme drouth."

Potato Scab.—The unsightly appearance of many tubers is due to scab. This is a fungous disease with which most growers have opportunity of acquaintance. An immense amount of work has been done by our Stations in study of the disease and in attempts to prevent its ravages. Some years ago the scab was attributed by growers and investigators to a variety of agencies, such as stable manure, insects, lime, etc., but the Connecticut and North Dakota Stations demonstrated beyond chance of doubt that the injury to the tubers is produced by a fungus (*Oospora scabies*). The following statement, taken from Bulletin 19 of the North Dakota Station, states the facts concisely:

"Potato scab is due to the growth of a fungus upon the young potato tubers while they are developing in the ground. The disease is communicated to the new crop by way of the seed tubers, or by way of the soil or old potato tops, if the potatoes are planted upon old ground, the germs having remained over from previous crop. If an old potato patch is in the near neighborhood the disease may also be communicated by wash water, or, perhaps, through dust blown from the old patch. If, however, there are no disease-bearing

tubers planted, and the ground used is ground that has never been used for potatoes, and care is taken that refuse from a previous disease-bearing crop does not reach the soil of the new crop, one may expect it to be free from the disease.

"Since the parasite is microscopic, one cannot be sure that there are no spores of the disease on the seed potatoes, though they appear to be smooth."

Control of Scab.—Growers have observed that an application of fresh stable manure, lime, wood-ashes and similar material very often gives a scabby crop, and this is due to the favoring effect of these substances upon development of the scab fungus. They can not produce the disease, but they may put the soil into such condition that the scab germs in it multiply and thrive. On the other hand there are materials that either destroy the germs or else create such soil conditions that the germs do not grow. The results of Station tests are very numerous and very conflicting, but the conflict is largely due to the variation in soil conditions, and it is now possible to make an accurate statement of some of the truth about the control of this disease.

Treatment of Seed.—The germs of the fungus may be on the seed to be planted, and not in the soil at all. When this is the case, a fair degree of control of the disease may be obtained by the treatment of the seed with a fungicide. Probably there is none superior to corrosive sublimate. Under this head I quote Professor Green, of the Ohio Station, Bulletin No. 76:

"The usual recommendation for the treatment of seed potatoes is to soak the seed for one and one-half hours in a solution of corrosive sublimate, two ounces to thirteen gallons of water. This treatment is efficient, but so long an exposure to the solution reduces the vitality of the potatoes somewhat, varying with the variety and condition of the seed. The matter of time at the busy season of the year is of considerable importance, and this feature alone often prevents the use of the treatment. For two seasons we have been soaking the seed one hour only, and find the result to be entirely satisfactory. Some experiments conducted last season indicates that the length of time may be still further reduced, without detracting from the value of the treatment.

"Complaint has been heard that treated seed, if kept several weeks before planting, loses its vitality. This may be true if the seed be stored in tight boxes or barrels, without drying, but we have kept treated seed in crates for several weeks without injury, although in a cold storage room, where the risk would be less than in a higher temperature."

Later experiments have shown that forty-five minutes is a sufficient length of time. In my own experience a convenient method

of treatment is to use water barrels, setting them on boxes on the ground where potatoes are to be spread for drying. When a barrel has been filled with potatoes, the solution is poured on, and at end of treatment it is drawn off in buckets and poured into another barrel of potatoes while the treated barrel is overturned on the ground. This is speedier than bagging the potatoes and immersing them in barrels of the solution, but the latter way may be made slightly less laborious.

Scab in the Soil.—When the scab fungus is in the soil, as is very frequently the case in old potato sections, there is no treatment of the seed that will insure a clean crop, but the effects of the disease may be controlled in degrees varying with the character of the soil. In the first flush of success with the corrosive sublimate treatment of seed, the claim was made that fertilizers and soils exercised no influence upon the development of the disease, but this is an error. Seed potatoes that are suspected of any contamination with scab should be given treatment to kill the germs upon them, and such seed planted in infested soil will give a cleaner crop than untreated seed will give, but still the product may be unmerchantable if the soil conditions favor the multiplication of the germs already in it. Success in the fight against potato scab must depend in part upon a control of soil conditions that will bring the destruction of the germs already in it.

It was once held that the rational means of cleaning an infested soil consisted in crop rotation, and such rotation is an aid, but we now know that the germs live in a soil six or more years without a potato or beet crop to feed upon. It is probable that the improvement resulting from ceasing to grow potatoes in an infested soil for five or six years is not caused by any "starving out" of the germs through absence of potatoes as hosts for this fungus, but is due to a change in soil conditions caused by some intervening crops.

"Souring" the Soil.—My attention was called urgently to this matter seven years ago when one potato field in the farm had become so full of the scab fungus that the crop was unmarketable. There had been increase in scabbiness for a term of years. A farmer made the statement in my presence that he never failed to grow a potato crop free from scab when planting in land that had had a winter cover crop of rye. For seven years the experiment has been made of growing a crop of potatoes in this field on a sod of fall-sown rye, and the results have been very interesting in several ways. Incidentally I may say that the yield this season of the seventh successive crop of potatoes was 285 bushels per acre, and during these years little had been done to aid the rye in maintaining fertility except to apply phosphoric acid in form of an acid phosphate. But the experiment was conducted in part to determine something about the control of scab in the soil. The seed was left untreated, and

the first crop taken off the rye sod was merchantable, though somewhat scabby. The next year the potatoes were more nearly clear of the disease, and in the third year the appearance of the tubers was excellent. Some traces of disease remained, but the extent of its presence was immaterial from the standpoint of a grower. I emphasize the fact, however, that I used varieties most resistant of scab.

This rye was plowed down each spring in the first hot days when the growth was about one foot high, and acid was produced by its decay. Experiments at the Rhode Island Station were showing clearly that the scab fungus delighted in an alkaline soil, or one treated with lime, and that it made little development in an acid soil. The natural inference was made that a growth of rye plowed down in warm weather would cause the formation of sufficient acid to prevent the growth of scab, and this remains true for some soils, but not for all. Some land is neutral or slightly acid, as shown by the litmus paper test, and any body of green vegetation rotting in it would produce a decidedly acid condition, unfavorable to the scab fungus. In the case of such soil it appears feasible to destroy the fungus by producing acidity in it by green manuring.

Other land is alkaline, and, if it is so in marked degree, a green crop rotting in it would not produce any excess of acid. Farmers are aware that some land may be "soured" to the point of unproductiveness by green manuring in midsummer while other land will not become "sour" through the practice. Likewise may land infested by the scab fungus be made sufficiently acid through the plowing down of a coat of green stuff in the spring to prevent much development of the fungus, while other land, strongly alkaline, would not be rendered acid and unfriendly to the fungus in this way.

Lime corrects soil acidity and thus promotes development of this disease. It is unwise to use lime on land immediately preceding a potato crop, provided there are any scab germs in the soil or on the seed, and the same is true of fresh stable manure.

Sulphur for Scab.—The New Jersey Station obtained some striking results from the use of sulphur on the land at the rate of 300 pounds per acre in the row, the seed being treated with it also. A series of experiments indicated that a sovereign remedy had been found, but tests elsewhere brought out the fact that soil conditions are a prominent factor, and that while the sulphur, like a green crop plowed down, would check the fungus in some soils, it was only slightly effective in other soils.

Some Station Conclusions.—From special Bulletin "S" of the New Jersey Station I take the following:

"In soil known to be thoroughly infested with the germs causing

potato scab, the fungicidal properties of a considerable number of substances have been tested during the past six years.

"Lime, gas-lime, kainit, corrosive sublimate, sulphur, Bordeaux, cupram, oxalic acid, sulphate and sulphide of ammonium, bi-sulphide of carbon, sulphuric acid, kerosene, formalin, creolin and benzine have each been added to the soil, and nearly all have had no effect upon the scab. A few reduced the disease somewhat, as corrosive sublimate, Bordeaux and cupram, but not enough to render them of practical value. Lime increased the percentage of scab.

"Of the whole list, sulphur only has yielded results which warrant it being recommended to potato-growers as a preventive of scab. It is not uniformly active, depending, probably, upon the conditions of soil temperature and moisture.

"For practical use, 300 pounds applied to the open row are deemed sufficient. It is also best to roll in sulphur the freshly-cut 'seed,' as it prevents rapid drying out of the water.

"The soaking of scabbed potatoes in corrosive sublimate has not proved of much practical value when they were planted under the conditions of the experiment, namely, in badly scab-infested soil.

"Uninfested soil may be readily contaminated by the introduction of scabbed potatoes or beets. The germ of potato scab, while not readily destroyed by boiling, seems to be largely destroyed by passing through the digestive tract of cattle. Special exposure (ridging) of scab-infested soil to the elements during the winter months does not appreciably affect the vitality of the disease. Susceptibility to scab is greater in some varieties of potatoes than in others.

"No plants, save the potato and beet (and probably the radish and turnip), have been found subject to root scab. All attempts to inoculate various species, both wild and cultivated, many of them closely related to the above named hosts, have proved unsuccessful.

"Experiments have demonstrated that the scab fungus is actively retained in the soil for at least six years without the presence of potatoes or beets."

In connection with the above, I ask that a close reading be given the following summary of Bulletin No. 40, of the Rhode Island Station, believing that the results stated make plain much truth about this fungous disease:

"The results from the use of sodium compounds and oxalic acid in connection with barnyard manure confirm those obtained in 1895, viz., common salt (sodium chlorid) tends to lessen the amount of scab. Soda ash (sodium carbonate) tends to increase the scab. Oxalic acid tends to lessen the scab when used with barnyard manure only or when common salt or soda ash is present.

"2. A scabless product was produced where calcium chlorid or land

plaster (gypsum) was used. Calcium chlorid had a marked poisonous effect upon the potato plants and nearly destroyed them. Land plaster appeared not to have increased, and it may have lessened, the yield slightly. Where calcium at the same rate as in the calcium chlorid and land plaster was applied to the form of wood ashes, air-slacked lime, calcium carbonate, calcium oxalate and calcium acetate, the vigor of the plants and the yield of tubers were wonderfully increased, but the crop was so badly scabbed as to be worthless.

"3. Where the fertilizer was used without any lime compounds no scab resulted, showing that the acid soil must have rendered dormant or destroyed the scab fungus introduced on the scabbed seed tubers of the two previous years.

"4. The treatment of the seed tubers with a 1 to 1,000 solution of corrosive sublimate for one and one half hours was utterly useless where the soil was favorable to the disease and where it was already badly contaminated by two preceding lots of scabbed seed tubers and scabbed crops. In other experiments by us heretofore where the soil was favorable to the disease, but where little or no contamination already existed, Bolley's corrosive sublimate treatment proved highly effective. It is probable that some germs escape even this treatment, but fewer, of course, where the seed tubers are not scabbed, so that there is danger if potatoes and root crops are grown frequently that serious contamination may nevertheless result eventually. The necessity, on land intended for potato growing, of avoiding the frequent use of fertilizers which tend to make the soil more favorable to the development of the scab fungus is therefore obvious.

"5. The materials which favor the scab and which are at times applied to land are: Stable manure of all kinds, wood ashes, air-slacked or caustic lime and carbonate of soda (soda ash), potash, lime and magnesia.

"6. The materials which do not tend to make the scab and which may decrease it, are most commercial fertilizers, seaweed, potash salts (excepting potassium carbonate), land plaster, common salt and ammonium sulfate. Sodium nitrate (Chili saltpeter), if used in large quantities, may favor the scab eventually, but from the amounts usually applied no serious results would be expected to follow. In case a soil were badly contaminated and favorable to the disease, super-phosphate, ammonium sulfate, kainit, sulfate and muriate of potash are materials which, applied as fertilizers, would tend gradually to alleviate the conditions.

"7. Sulfur when mixed thoroughly with the upper seven to eight inches of a badly contaminated soil favorable to the disease, though checking the scab somewhat, was practically useless.

"8. The treatment of seed tubers by rolling in sulphur and sprinkling the balance in the row at the rate of 300 pounds per acre is claimed by Halsted to be quite effective. The use of the very poisonous corrosive sublimate solution would be thereby avoided, yet the additional expense of the sulfur over the corrosive sublimate treatment for this purpose militates against its use in that way where potatoes are grown at the present low prices.

"9. The marked acidity (sourness) of soils, or the absence of carbonates in them, seems to indicate their ability to produce a scabless product even when untreated seed tubers are used."

OUR CONCLUSIONS.

When danger of scab threatens, all seed should be treated with corrosive sublimate or Bordeaux mixture before planting, and the land should not be given an application of fresh stable manure or lime within a year of planting. Rotation of crops is desirable. If the soil is infested with the fungus, an attempt should be made to produce some acid in it by plowing down a green crop, like rye, in the spring. Lime should not be applied. Rolling the cut seed in sulphur before planting and applying 300 pounds of sulphur in the row, may give good results. Some varieties of potatoes are much more subject to injury from this fungus than others are. Select resistant varieties.

On the other hand continuous planting of potatoes and the use of manure will not bring scabby crops if the fungus germs are not present, or if they are kept in control by the acidity of the soil. Clean seed, made so by treatment of good tubers with the solution of corrosive sublimate, and selection of resistant varieties do much to save from loss. Drainage is an aid, in that it removes a surplus of moisture. Experiments with irrigation of potatoes indicate that water favors scab development, and in our own experience the disease is worse in wet seasons than in dry ones. Early digging is advisable when scab is present. While most scientists regard the worst roughening of the skin as an effort of nature to heal the injury made by the fungus, yet there is evidence that the injury continues after maturing of the tubers when left in the ground. Exposure to light checks its work. The budding of seed in the sunlight before planting destroys the vitality of the germs.

Rhizoctonia.—A disease that is new to potato-growers in this country is appearing in fields in many States. In the annual report of the New York Station for 1900, attention is called to it, and we learn that it was observed over ten years ago in Iowa. In 1900 I found the disease in one of my fields, losing two-thirds of the crop by its ravages, and learn from our Station workers that it is the soil

fungus, rhizoctonia, which attacks the roots and stems of many cultivated plants. The first indication of its presence is found in the wilting of the leaves in the buds. The edges turn inward, giving the plant a lighter appearance. The wilt continues, and examination of the stem shows discoloration. The presence of the fungus in the stem appears to shut off the circulation of the sap, and in bad cases the vine will turn yellow quickly. In other cases, the injury to the stem may be sufficient only to dwarf the growth of the vine. The fungus may attack the stems that feed the tubers, checking their growth and giving only small potatoes from large vines. In 1902 this disease again attacked a field of potatoes on the farm and gave promise of most severe injury, but it was checked by some unknown means—most probably by a period of cool, dry weather—and while some plants were too badly affected to recover, a majority did so, losing the wilted appearance and giving a good yield of large tubers. It is known that the germs are transmitted on the seed, and that when they are in the soil it may remain infested for many years. Station authorities advise treatment of the seed with corrosive sublimate and liming of the land. The spraying of affected vines with any fungicide can not affect the disease which is lodged inside the stem of the plant.

HARVESTING AND STORING.

Potatoes keep best when they can be left in the ground until the cool nights of September, if the season is dry. In a very wet season, ripe potatoes left in the ground may make a second-growth, sending up sprouts from the eyes, and there is danger also of rot. But it is not easy to keep potatoes stored in quantity in very hot weather, and it usually is better not to dig until early in the fall unless the crop can be marketed at once. Just as soon as the nights become cool, the potatoes can be stored safely in piles in the field under a covering of straw, or in cellars. Any tubers cut by steel in digging should be taken out of a lot intended for early storage as they will rot in a warm splace. This is equally true of potatoes for early shipment to a distant market.

Diggers.—Formerly the crop was dug largely with hoes, hooks and forks, but the lack of cheap labor has brought a number of kinds of good implements for harvesting the crop. In loose soils, and especially with shallow planting and ridge culture, some of these diggers do nearly perfect work. The best digger is one that lifts up all the soil in the row with the potatoes, sifts the soil back into the furrow it makes, and leaves all the tubers lying on the surface. The digger that elevates the mass of earth in the row, and gives

time for thorough sifting before the potatoes are dropped upon the ground, does the best work, but it is, of course, at the expense of extra power. Such diggers are expensive, but in loose soils they soon repay their cost. There are cheaper diggers that do excellent work under favorable circumstances. In the selection of a digger the matter is one of arithmetic largely. The cheaper the price, the fewer facilities it has for sifting the soil away from the tubers, as a rule, and one must be governed by the acreage he has to harvest, and the market price of potatoes and of human labor.

For heavy soils in which potatoes are planted deep, it is not possible to have a digger that will be easy on horses, and yet do satisfactorily clean work. There is a large volume of soil to be moved by the digger, and there is difficulty in securing a perfect separation of the potatoes from the soil. It is not our purpose to call attention to the merits and demerits of any of the diggers now on the market, but to remind growers that soils and methods of planting and of culture vary so much that no investment should be made without a field trial. Clean work should be made a leading consideration, as we want to secure what we have produced, but the power required and the wearing qualities of the emplement should be taken into account.

Potato Boxes.—In great potato-growing sections years ago it was a common practice to pour bulk potatoes into wagon-beds, and to shovel them out into baskets when unloading. This primitive method was laborious, and did injury by bruising the tubers. Potato boxes have now come into common use in many districts. They are made of light material, preferably bass-wood, or similar wood. The boards for sides and bottom should be three-eighth inches in thickness, and the ends one-half. The size of box should be such that it will contain 2,688 cubic inches, level full. The legal bushel measure for grain contains 2,150.4 cubic inches, and in measuring roots or potatoes the rule is to heap the half-bushel measure sufficiently to add one level peck to the two level half-bushels. Five level pecks, or 2,688 cubic inches, are the equivalent of two rounding half-bushels, and of a level potato box rightly made. The following dimensions are the ones used by a leading manufacturer of these boxes: Twelve and one-half inches deep, thirteen and one-half inches wide and sixteen inches long. This gives exactly 2,700 cubic inches. This size probably is more convenient than any other that could be devised. The length of two boxes is near the width of the ordinary wagon-bed, leaving only room for the hands when putting them into position, and, when empty, one box can be placed inside of two others, economizing space. With high side-boards on the wagon bed it is convenient to tier up sixty bushels when drawing from the field to the cellar, or to market, but the extensive grower may prefer

a long platform that will hold twenty or more boxes in a single tier.

The home-made box is usually less satisfactory. It is made rarely of the best light material, and when one takes into account the number of times the boxes must be handled, he may see the advantage of having the very best. Manufacturers furnish solid boxes that weigh only seven pounds, are exact in size, trim in appearance, and will last for fifteen or twenty years, if cared for properly. Other boxes, slatted on ends and sides, are furnished at a less price, and are less substantial. The boxes, bought in crates of a dozen, cost about eighteen cents a piece for the solid ones and fourteen cents for the slatted.

The potatoes are picked up after the digger and placed into the boxes, the unmerchantable tubers being left on the ground. When a load is ready, the boxes are handed up to the driver of the wagon, and while he takes the load to the car, cellar or other place of storage, another load is made ready by the pickers. Returning, the driver puts his empty boxes out, takes on his load of full ones, and the work proceeds with a minimum amount of handling. If the potatoes are drawn directly to consumers, neat boxes for handling them are a good advertisement as well as a means of saving labor, time and injury to the stock.

When good seed, cut to two eyes, has been planted in good ground, and the tillage has been right, the number of unmarketable potatoes usually is small, and many years we do not pick them up. It is the practice of some growers to pick up all sizes together and then to sort out those that are not merchantable, using the best of these for planting and the remainder for stock feed. As has been said in another place, the small tubers are not the most desirable for use as seed. If there is a considerable proportion of the crop that is too small for market, it should be gathered from the ground after the merchantable potatoes have been taken up.

Storing Potatoes.—Winter storage should not be provided until the weather is cool. If the potatoes are put into large bulk in cellars, pits, or piles on the ground in hot weather, they will sprout quickly in a warm winter. In the case of seed potatoes, I have found it well to store temporarily in cellar in the fall, moving them outside for burying when the weather is cold. A good plan is to scatter some straw over the ground intended for their burying, and then wait for a freeze. Remove the straw when the temperature is above freezing, and put the potatoes into narrow ricks on the unfrozen ground. Cover to a depth of six inches with dry straw, and then put on six inches of earth. This covering of soil will freeze quickly in cold weather, and then another covering of straw should be added, and on this soil manure or corn-stover may be placed. With this method, the potatoes are cool when buried and the ice in the under

covering of earth is held in it throughout the winter, giving a very good and cheap cold storage until time for early planting. Farther north, the more complete protection by pits is desirable. Storage of seed in ordinary cellars does not give good results in warm winters. A cold-storage building may be provided, having warm walls, and good means for ventilation in cool nights of spring and for exclusion of the warm air of mid-day, and potatoes may be kept unsprouted thus without any ice until quite late in the spring. Make the walls double, with dead-air space between them, have the floor proof against rats and water, and admit the cool air through chutes under the bins, letting the warm air pass out through a ventilator. When the room has been filled with cold air, close tightly. The temperature should not be permitted to drop below thirty-five degrees Fahrenheit for any great length of time. That is near enough the freezing point for safety. Chilled seed is as unsafe for planting as heated seed, and either invite loss and disappointment. Darkness is essential to the proper keeping of potatoes for seed or eating.

Shrinkage in Storage.—Potatoes lose in weight rapidly for a few days after the digging, either when left in boxes or put into piles in field or cellar. The greatest product is gotten by immediate marketing. After the sweating they undergo in the bin or pile, the loss is not great until a tendency to sprout manifests itself. Then shrinkage occurs either through the sprouting or the stirring given to prevent sprouting. The amount of shrinkage is so dependent upon variety and kind of storage that no figures of special value can be given. Roughly speaking, the shrinkage in cellars from storing time until spring is eight to fifteen per cent. In cold pits it may be less. In warm cellars the loss, including normal decay of cut or bruised tubers, sometimes exceeds fifteen per cent. by the first of May.

POTATOES AS FOOD.

Professor Storer, in his valuable work on Agriculture, remarks that "it has been said that the famines which formerly devastated Europe became much less frequent after the potato was cultivated as a field crop. Before the introduction of the potato it happened constantly, every six or eight years, that somewhere on the continent of Europe the inhabitants of large tracts of land suffered from dearth because their grain crops had failed."

According to Dr. Langworthy, the potato is probably a native of Chile, being introduced into Europe between 1580 and 1585, and into our country about the same time. Its food value was quickly appreciated, and it is a staple article of diet. From the year-book of the

Department of Agriculture, I quote the following, by Dr. Langworthy, of the Office of Experiment Stations:

"Cooking of Potatoes.—Although the potato owes its nutritive value principally to carbo-hydrates, it will be remembered that it contains some nitrogenous matter also. According to the investigations of Lawes and Gilbert, the juice of the potato contains more proteid or albuminoid nitrogen than the flesh. This is an important matter, since albuminoid nitrogen is more valuable for the body than non-albuminoid nitrogen. In general, it may be said that 85 per cent. of both protein and mineral matter in the potato (the latter being valuable for dietetic reasons, though not a nutrient) is in the juice. More or less of the juice of any food may be accidentally lost when it is prepared for the table; and the possibility of loss in cooking, due to this and other factors, is a matter of importance. Any sugar or other soluble carbo-hydrates might be removed if potatoes were cooked by boiling. No considerable loss of starch as such is to be expected, since starch is insoluble in water. Some starch is changed to a soluble body, dextrin, a sort of sugar, by the action of dry heat, possibly also when water is present.

"The principal ways of cooking potatoes are baking, boiling and frying, or some modifications of these processes. The objects sought are principally to soften the tissues and render them more susceptible to the action of the digestive juices and to improve the flavor. Just why cooking changes the flavor, as it does, has apparently never been made the subject of investigation. In potatoes, as in other foods, the cooked starch is more agreeable to the taste than the raw. Possibly also there are volatile bodies of more or less pronounced flavor, which are removed or produced by the heat of cooking. The physical condition of the potato is much affected by heat. In the raw potato the separate starch grains are inclosed in cells with walls composed of crude fiber, a material resistant to digestive juices. If potatoes were eaten raw, the digestive juices would not reach the starch as easily unless the cell walls happened to be ruptured mechanically, as in mastication. Heat, however, expands the water present, ruptures the cells, and breaks up the starch, expanding the granules, which, when raw, consist of tightly-packed concentric layers, to a mass of much less solid structure.

"The albuminoids in foods are coagulated by heat, and so are rendered insoluble in water in which food is cooked. This explains why foods, meat especially, should be plunged into boiling water if it is desired to retain the albuminoids. The heat at once coagulates the albumen on the surface, thus preventing more or less completely the extraction of materials in the inner portion. It seems probable that this reasoning would apply to potatoes as well as to meat, although they contain much less albumen. The effects of cooking po-

tatoes by boiling in different ways were tested not long ago at the Minnesota and the Connecticut (Storrs) Agricultural Experiment Stations. The potatoes were boiled in distilled water, limewater, and alkaline water; part were boiled in water hot at the start and part in water, cold at the start. In some cases the potatoes were peeled before boiling and in some cases this was not done. In two tests the peeled potatoes were soaked before boiling. The total loss of material (dry matter) ranged from 6.5 per cent. of the total amount present in the case of the peeled potatoes soaked before boiling to 0.2 or 0.3 per cent. in the case of the potatoes boiled with the skins on. The greatest loss of total nitrogen and ash were also found when the peeled potatoes were soaked before boiling; least when this was not done. Whatever the method of boiling, little of the carbohydrates was lost. From the experiments as a whole, it may be said that when potatoes are boiled with the skins removed there is a very considerable loss, not only of organic nutrients, but also of mineral salts. To obtain the highest food value, potatoes should not be peeled before cooking. When potatoes are peeled before cooking and placed directly in hot water and boiled rapidly, less loss of materials is sustained than when they are cooked in water cold at the start. If potatoes are peeled and soaked in cold water before boiling, the loss of nutrients is quite considerable; in the case of proteids, being equal to one-fourth of the amount present. The loss in a bushel of potatoes thus cooked would be equivalent to the albumen in a pound of sirloin steak. When potatoes are boiled with the skins removed the greatest actual loss of nutrient seems to be due to the mechanical abrasion of some of the soft outer portions while cooking. In the experiments at the Connecticut (Storrs) Agricultural Experiment Station it was found that nearly three per cent. of the carbo-hydrates and four per cent. of the albuminoid material were lost when potatoes were thus cooked. When the potatoes were boiled with the skins on, the loss of nutrients was very slight, consisting chiefly of non-albuminoid nitrogenous substances and mineral matter. It is, therefore, evident, if it is desired to boil potatoes with as little loss as possible, that the skins should be left on.

"Comparatively speaking, there are probably few cases in which it is necessary to take account of the losses due to different methods of boiling potatoes and where the possibility of loss would outweigh the liking for them prepared in some particular way; but in institutions where a large number must be provided for, and, in fact, under any condition where rigid economy is necessary, the matter may assume considerable importance.

"An extended study of the relative composition of large, medium, and small potatoes, and of the different parts of the tubers and of the taste and culinary properties, was recently reported by Coudon

and Boussard, two French scientists. The authors believe that the culinary value of potatoes is directly proportional to their nitrogen content and inversely proportional to their starch content. The different varieties of potatoes were found to vary greatly in their resistance to boiling, some retaining their form completely, while others were almost wholly disintegrated. The opinion was advanced that resistance to boiling depends principally upon the relative amount of albuminoids present. No definite relation was observed between chemical composition and early maturity. Generally speaking, the early varieties contained more water and nitrogenous materials and less starch than the late varieties tested.

"As regards chemical composition, it may be said in general that boiled potatoes contain a little less water than raw potatoes, and except as this changes somewhat the proportion of nutrients, they differ little in composition from the raw. Mashed potatoes, if they are not seasoned, must necessarily have the composition of the unmashed boiled potato, making allowance for the small proportion of water which would probably be lost by evaporation in mashing. When milk, cream or butter is added to mashed potatoes in preparing them for the table, the nutritive value is increased, though the chief reason for adding such materials is doubtless to improve the flavor. This is also the reason why salt and pepper are added. Baked potatoes have practically the same composition as the uncooked, some water being lost by evaporation. When potatoes are fried, as in making potato chips, they lose by evaporation much of the water present and absorb more or less fat. They, therefore, have a higher nutritive value, pound for pound, than raw potatoes. Potato chips have been found, by analysis, to contain two per cent. water and 39.8 per cent. fat, as compared with 78 per cent. water and 0.1 per cent. fat when raw. The many ways of cooking potatoes, with or without the addition of other materials, which are described in books devoted to cookery, are, in principle, modifications of those already alluded to. The wholesomeness of potatoes cooked in different ways is largely a matter which each must decide for himself, the general experience being that for men in health most of the methods followed are satisfactory.

"Evaporated potatoes are now on the market, being especially recommended for provisioning camps and expeditions. As compared with fresh, the evaporated potatoes have a high nutritive value in proportion to their bulk. This is the case with all evaporated foods, such material having been concentrated by the removal of a large proportion of the water originally present."

Potatoes for Live Stock.—Many experiments have been conducted to determine the value of potatoes for feeding to farm animals. It is found that they have a value as an aid in digestion of dry feeds

that may exceed their own actual food value. The potato is largely water, and in the feeding of thousands of bushels to horses, cattle and sheep, we have been led to believe that a bushel of corn at forty cents is as cheap feed as potatoes at ten cents, excepting such small amount as may be needed to aid digestion. Experience and Station experiments indicate that potatoes should be cooked for hogs and poultry, but that they may be fed raw with profit to horses, cattle and sheep.

THE MANAGEMENT OF GREENHOUSES.

By Edwin Lonsdale, *Wyndmoor, Pa.*

INTRODUCTORY.

While greenhouses for the growing of a general collection of plants have long been in use, commercial greenhouses for the growing of cut flowers, especially for winter, are of comparatively recent development, dating back not much more than twenty-five years in Pennsylvania.

In the spring of 1880, an establishment was started near Philadelphia—modest in its proportions, it is true—in which to grow cut flowers to be disposed of under wholesale arrangements. There were three greenhouses, each one hundred feet long. The one for roses was twenty-three feet wide. In that house were grown five varieties, namely: Safrano, Isabella Sprunt, Bon Silene, Niphetos and Perle des Jardins, none of which are grown in any quantity for winter blooming at the present time in or near to the larger cities. Another house was for Carnations, and the variety grown was principally, King of the Crimsons. This variety found ready sale on account of its color to help out the celebrated crimson rose, General Jacqueminot ("Jack"), which was at the height of its popularity about that time. The third house was devoted entirely to Smilax, botanically known at that time as *Myrsiphyllum asparagoides;* now, according to Bailey it is classified as an *Asparagus*, *A. medeoloides.* At this time little or no other green was grown to associate with flowers, excepting, possibly, Maidenhair Fern—*Adiantum cuneatum*—and that in very limited quantity. This house contained about 3,500 plants, which proved at that time to be more than Philadelphia could use to advantage. Florists in the cities of New York and Washington, however, were only too glad to take the surplus, and for several years, florists of the two cities named depended largely upon this establishment for much of their Smilax supply. Smilax was at that time an excellent paying crop, frequently yielding one dollar per square foot, which is considered very profitable.

Other greens have come since that time which are more popular than the older Smilax, as *Asparagus plumosus nanus, and A. Sprengerii* the former of which twines itself on strings as does the Smilax. and houses very high are built especially for its cultivation; whereas, *Sprengerii* grows in plumes or sprays and are cut in lengths from nine to eighteen inches, and are sold in bundles of about twelve plumes each, averaging about fifty cents per bunch.

Asparagus tenuissimus, known to some extent as "Mermaid's Hair," was the first to dispute the position occupied for so long by Smilax, but for some reason it seems to have entirely gone out of cultivation, especially about the larger cities. According to Bailey, *tenuissimus* is a variety of *plumosus nus;* which would never be suspected by the casual observer. Mermaid's Hair, describes it very well, being very finely cut indeed, resembling greenish mist.

Another green grown is the *Adiantum Farleyense*, the Queen of Maidenhair Ferns, and it richly deserves that name. No fern, however, at present in commerce, is so well suited to go with flowers as are the different varieties of Aspargus on account of the tendency to wilt so soon. There is, however, a new Adiantum (Maidenhair Fern) to be sent out soon which is similar to *Adiantum cuneatum*, and is far superior to any other in its lasting qualities after being cut, and for that reason when it becomes better known must become popular.

GREENHOUSE PLANTS AND VARIETIES.

It can hardily be questioned, I believe, that the growing of plants in the window was the fore-runner of the greenhouse structures of to-day, in which to shelter exotic and other tender plants from frost and to force flowering plants into bloom out of their natural season. Great improvements have been made in the building of greenhouses during the past twenty five years; especially does this apply when used in floriculture and the growing of plants for decorative purposes, which come under the head of ornamental horticulture.

The first greenhouse built would, it is natural to suppose, be an attachment to a residence, and in those early days what are termed "lean-to's" were the most generally in use. The term "lean-to" means that the wall, which was a part of the residence, upon which the greenhouse appeared to lean was utilized as one side of the structure, and the sash-bars were secured at the top to the house side and at the lower end to a wall low enough to give the necessary angle to allow rain and snow to fall naturally therefrom, and at the same time to give the sun an opportunity to reflect his life-giving rays therein. And the methods employed in these days also are to build greenhouses to catch every possible sun ray, that is to say, when such a structure is erected for the purpose of producing flowers in the more or less frosty nights and cloudy days of winter, with some exceptions, which will be noted in due course.

The variety in styles of greenhouses now in use is almost infinite. Indeed each individual has his own ideas which he has naturally embodied into a plant-growing structure.

In regard to growing plants under glass, flowering plants are especially in mind. Among the most popular flowering plants for cut flower purposes to-day that are hardy, or very nearly so, we note here.

We will place the Rose first, and with very slight protection from severe frost, all the popular varieties used in the winter season are, speaking generally, hardy. That is also true to a great extent with the Carnation and the Chrysanthemum; and in the Lily of the Valley it is quite true as to its thorough hardiness, and which, by the way, may be had in flower, if due notice is given, on any day at any time of the year. This is brought about by a systematic arrangement with cold storage, in which to keep the roots dormant until the proper time.

We have the exotic Orchids for cut flowers, but Roses are really the most popular flowers before the public at the present time, and observers of events feel they can safely say that the Rose, the "Queen of Flowers," will for all time hold the affections of the people. To the laymen, if I may be allowed to so designate those who are not in close touch with the forcing of Roses for cut flowers commercially, it may seem strange when I say that out of hundreds of species and varieties and of Roses in and out of catalogues and books of reference, there are less than a dozen which are recognized as being both profitable and popular for the purpose indicated.

As to varieties, American Beauty stands first on the list. Its cerise color is too well known to need anything more than a passing mention here. Its sweet June Rose scent endears it to all, besides being a Rose which when well grown may be cut with almost any length of stem desirable. For special purposes, flowers with stems eight feet long have been cut—these are the most expensive of any; not that the individual flower is any better on these extremely long stems than on shorter ones, because they are not. Frequently the flowers on a stem a foot long or even shorter will be equally as perfect in form, size, color, and, of course, fragrance, as those with a much longer stem. It is the scarcity of these very long stemmed flowers, and the special uses to which they may be put, which makes them more valuable and consequently higher in price than the shorter ones. This Rose may be bought all the way from one dollar to twenty-five dollars per dozen, according to the season of the year and the length of stem and quality of the flower, but the fragrance, bear in mind, is always found in the flower no matter how long or how short the stem or how far from perfect may be the flower in form.

The origin of American Beauty Rose is in doubt. A claim is made that it was discovered in the garden of the late historian, George Bancroft, at Washington, D. C., who was a great lover of Roses and had a collection of numerous and choice varieties. It was the gardener for Mr. Bancroft who discovered it first, but whether he thought he could see that it possessed a possible forcing quality or whether by accident it was found out, has not to my knowledge been placed on record. Certain it is that more area under glass is devoted to its culture for the large cities, as Philadelphia, New York, Chicago and Boston, than all the other varieties of winter forcing varieties combined.

Although we owe much to the florists of Boston for having been the pioneers in the development of Rose forcing in general, yet the American Beauty, for some unaccountable reason, has not in the past been grown thereabouts so successfully until the past year or two when better reports have been recorded; consequently

the Boston retail florists have been depending upon the Rose growers about Philadelphia and some other localities for the greater part of their supply therefor. There are evidences, however, that many more of the flowers of the American Beauty will be home grown for the Boston supply in the future than there have been in the past, for some immense structures have been built near to that city for the purpose indicated during recent years. Rose houses 750 feet long and 25 feet wide have been built within the past two years, in which, we believe, only American Beauty Roses are grown.*

When the American Beauty received so much attention in the American horticultural magazines, the European horticulturists naturally became interested, and, in consequence ,ordered plants of same. In due course these plants flowered, and thereupon a French nurseryman recognized in it an old variety by the name of Mme. Ferdinand Jamin, and duly spread the information broadcast in all languages where advanced horticulture is known. This, as a consequence, temporarily at least, gave American nurserymen a bad name—that of renaming an old variety and redisseminating the same, thus causing much confusion in Rose nomenclature, besides placing American disseminators of floricultural novelties under the ban. In the case under consideration it was purely unintentional. Besides, if it is in any way consoling, the European distributors of novelties have been guilty of the same kind of "slips"—that of renaming and redisseminating old varieties under new names.

An old friend of mine, fifteen years ago, in the columns of the American Florist, made the statement that American Beauty was the best Rose introduced for the past twenty years, and although he was ridiculed to some extent then, nothing but the truth was stated as time has proven. The grand blooms of this Rose that have been produced since were not dreamed of at the time the statement was made, but the improved methods of culture and a more exacting demand as to quality for all classes of flowers has helped along the good work.

From the American Beauty Rose has sprung two varieties, namely: "American Belle" and the "Queen of Edgely." Both originated as what are known among gardeners and florists as "sports," that is to say, a shoot produced a flower that was distinct from those produced by the parent plant. Cuttings, "slips" or scions were made from said shoot, and in due course plants and flowers resulted therefrom which proved to be sufficiently distinct to warrant the adopting of a different name. The color of the flowers of both sports, or, as Darwin would call them, "bud variations," were nearly

*In Connecticut during the present Summer (1902), a rose house 800 feet long by 50 feet wide was built, in which are now growing American Beauty Roses for the Boston market.

alike, being pink and very much lighter in color than those produced on the original American Beauty, though the general habits of the respective sports were very different.

The Queen of Edgely is similar to "Beauty" in all respects excepting the color of the flowers, whereas in "Belle" there is a decided difference, which is noticeable at a glance; the leaves are smaller and the variety is less vigorous than either of the other two, consequently more difficult to manage, and that is why the American Belle has never become popular with the growers of cut flowers for market. Many experts believe that had it possessed the strong vigor of either its parent or its sister-sport, the Queen of Edgely, it would have been grown in almost as large quantities as the American Beauty and as the "Queen" is expected to be grown. The latter was only introduced to general cultivation during the spring of 1901, whereas, the American Belle was disseminated in 1893. Both the American Belle and Queen of Edgely originated in Pennsylvania; the former, near Chestnut Hill, in Montgomery county, and the latter, near Bristol, Bucks county.

Other varieties of roses which have found favor with both flower buyers and the growers of roses, are the Tea-scented roses, Bridesmaid pink and the white one, Bride; and, strange as it may appear, both these originated as sports and both from the same source, namely ,from a rose sent out from France in 1869, named Mlle. Catherine Mermet, which has been almost entirely superseded by its offspring, Bridesmaid, which is a brighter pink and more constant in its coloring. Two other varieties sported from "Mermet," namely, "Waban" and "Maid of Honor," both a darker pink in color than the original and more flat in form, neither of which became popular. The Bride appeared in 1885, and Bridesmaid in 1892, both in New Jersey; Waban appearing in Massachusetts and Maid of Honor in Ohio.

"Golden Gate" is of American origin, and is another very satisfactory rose to grow, having a strong constitution and produces its beautiful buds plentifully. Its name is a misnomer, however, being neither yellow in color, nor did it originate near to the Golden Gate in California, but was raised from seed about the year 1890 by a Mr. Little, of New Orleans, La. In color it is creamy white, with a suggestion of yellow at the base, delicately tinted at the edges of the petals with pink. This variety has also sported a white form which has been named "Ivory." Its real value is not at present well known as it is not yet in general cultivation. It will be sent out during the present year (1902). It, however, is full of promise.

The "General Jacqueminot" or "Jack"—is not so much grown for winter blooming as it at one time was, being a one crop rose, and in order to try to keep up a continuous supply, several houses had to

be grown of it and started at intervals of two weeks or so with that object in view. "Meteor," being crimson in color and everblooming in character, has largely taken its place. It is, however, not so good a rose as the older favorite in any way, excepting in its perpetual blooming qualities. It has little or no fragrance, and it is not so large nor so good in form, nor is it so pleasing in its crimson coloring. This rose was raised from seed in England. A newer crimson-colored variety, known as "Liberty," was distributed for general cultivation during 1900, which is very much superior to Meteor in every way, excepting that it is not such an easy doer, being more difficult to manage, but is giving excellent results with some growers. Liberty was a seedling raised in Ireland.

"Perle des Jardins," a yellow tea-scented rose of French origin, was sent out in 1874, and for a number of years was very popular, leading all others for a few seasons and entirely superseding "Marechal Niel," a yellow rose blooming in crops with rampant growing tendencies, so much so that special houses were built in which to develop its peculiarities. Although the "Niel" was a large flower and a beautiful shade of yellow, the very short stems upon which the blooms appear would debar it on social and general occasions in these days of long, stout and erect stemmed roses, and would find little or no favor now, excepting possibly on special occasions.

From the "Perle" quite a number of sports have originated. The first was "Sunset," which appeared near to Jersey City, N. J., about the year 1880, and was a fawn shade of yellow in color, and the leaves on the young growth had a more reddish tinge than appears on the older Perle. This also became quite popular. "Senator McNaughton," a creamy white in color, originated in Philadelphia, but was not grown to any extent because it was not nearly so good in any way, save possibly in its free blooming qualities, a feature which distinguishes the most popular white rose to this day for winter blooming ever introduced, namely, the Bride. Another sport came from Canada, but this I am inclined to think sported from Sunset, and was called Lady Dorothea; the coloring was more intense in the latter than the former. Pink Perle and White Perle were announced from Kentucky, but neither made any impression upon the trade for cut flowers. "Sunrise" was one of the novelties among roses last year (1901). It is a European production and is very beautiful. It may be a sport from Sunset, as it has the same general habit as that variety, both in foliage and coloring of the flowers, but very much intensified. This variety has also sported. It perhaps would be safest to say, reverted, for so far the flowers produced on the sported branch are apparently identical with Perle des Jardins.

"Mme. Cusin," another French Rose, had a few seasons of popularity. It is a delicate shade of pink in color, beautiful in shade and form, though somewhat flat, and in its lasting qualities after being cut from the plant, it is far superior to all others. This also sported in New Jersey, and the resultant variety is known as "Mrs. J. Pierpont Morgan." The color of the flower is much darker, being a bright, though light shade of solferino; the flower is also larger than "Cusin," and its good keeping qualities are, if possible, even better. And "Mrs. Morgan" has recently sported in Massachusetts, this time to an exquisite shade of delicate pink. It has been named "Mrs. Oliver Ames," and will be disseminated for general cultivation during the present year (1902).

All roses may be forced into bloom out of their natural season, provided proper care is taken in the preparation of the plants and the subsequent care of same; but those named are the most popular and easier to manage than are the hundreds to be found in catalogues and books of reference. The tea-scented section and the Hybrid Tea, because naturally everblooming, are the easiest to manage in this respect, and need little or no preparation excepting to give them generous treatment so that they may be kept growing; but all the buds and blooms should be kept pinched off during spring and summer, without taking any part of the shoots excepting one eye and leaf possibly with the flowers. We have thought it best to allow the flowers to come into full bloom before they are removed, because the shoots which are left on the plants seem to break into growth much quicker than when pinched off in the small bud state.

Before closing these rose notes, I must say that the old favorites of twenty-five years ago, as Bon Silene, pink in color, Safrano, fawn color, Isabella Sprunt, yellow—a sport from Safrano— and Papa Gontier, dark pink, are all really easier to manage than are the Bride and Bridesmaid, but the flowers are considered too small for present general requirements.

Roses for cut flowers, whether grown by the trade for sale or by amateurs, are grown in soil on tables or solid beds, as taking less care than when grown in pots, though just as good flowers may be grown in pots as in any other way, but they require very much greater care in order to produce the finest flowers. American Beauty may be an exception to that rule, because the long stems required of this rose for the best and most exacting trade could not be produced in pots in sufficient quantity to pay.

It has been deemed advisable to thus treat upon roses at length, because if roses can be grown successfully in greenhouses, the operator need not hesitate to undertake to grow any other plant, as roses are among the most difficult plants to grow and bloom successfully that we have.

The question of temperature in the growing of roses is one of the most important, and nearly all the sections mentioned need a few degrees difference at night if we would achieve the greatest success. For instance we have found the Meteor must have five degrees higher at night, namely, 65 to 68 degrees, than American Beauty, Queen of Edgely and American Belle require, which to do their very best should have from 60 to 62 degrees; kept as nearly the first named number of degrees as possible is the better. Bride and Bridesmaid, 56 to 58 degrees, and Bon Silene, Safrano, Isabella Sprunt and Papa Gontier, 54 to 56 degrees, and Golden Gate, 58 to 60 degrees. Perle, Sunset and Sunrise, from 60 to 62 degrees.

A similar state of affairs exists with Carnations, though not quite to the same extent. Twenty-five years ago, from 40 to 45 degrees was considered about right for these popular flowers, but it is found now that for best results with the greatly improved varieties now being grown, a temperature about the same as that recommended and in use for roses in those days is now in use for Carnations, namely, about 55 degrees.

New varieties of Carnations are so readily produced, and are being raised in all parts of the country, that it is quite difficult to keep track of them all. One, named "Prosperity," should be mentioned, however, because it is such a decided step forward that it seems today that it will be some time before it is distanced. This was sent out last year. It produces the largest flower of any variety in commerce, with stiff, erect and long stems, and is white, marbled with pink, in color.

A scarlet variety, named "Adonis," should be mentioned also, as it is one of those superior varieties that looms up head and shoulders above all the rest and looks as though it had come to stay for awhile. It is brilliant scarlet in color, of large size, and has the necessary stout and erect stem. The raiser of this novelty lives in Ohio, and has sold same to two firms jointly, one living in Indiana and the other in Philadelphia. The purchase price for control of the stock is said to have been $5,000. It will not be put into commerce until the spring of 1903.

The price just named does not begin to compare with the price which is said to have been paid by Thomas W. Lawson, of Massachusetts, for the variety which was named "Mrs. Thomas W. Lawson," after the Copper King's wife. Said price was $30,000, but so well was the variety advertised and so many plants had been sold that the purchase money was reported to have been realized by the end of the month of February, when there were still remaining three good months in which to sell this sterling novelty. It has proven to be a grand variety, giving excellent results generally, which is

more than can be said for every new Carnation that is disseminated, many varieties being absolute failures in some sections of the country; whether it is the soil, the climate, or the water, which does not suit them has not yet been determined.

VENTILATION.

One of the most important matters in connection with the successful management of the greenhouse is the ventilation. It is very necessary, not only to keep the temperature within down to the mark, but it is also necessary in order to make as complete a change of the inner atmosphere as is possible.

In the olden time when greenhouses were frequently, we may say, generally built with sashes made for the purpose, the mode of ventilation was to slide them all down from the top, or as many of them as were left loose for that purpose, or according to the weather, and with the pipes for heating purposes arranged beneath the stages, thus a thorough circulation was made and the air changed.

Nowadays, however, few greenhouses are built with sashes, but instead, by what is known as a fixed roof, and arrangements are made whereby sashes are hinged at the apex and lifted by a machine made for the purpose, and by which the temperature may be regulated to a nicety.

There is an automatic ventilating apparatus on the market, which works with complete accuracy. It is operated by water pressure, but it cannot be operated satisfactorily unless there is guaranteed water pressure under control of not less than twenty-five pounds. This is a wonderful contrivance, and is a great labor-saving machine. Its cost, however, may seem to some prohibitory.

THE WATER SUPPLY.

The water supply is one of the first and most important matters to be considered in the starting of a greenhouse.

Not more than twenty years ago, even within city limits, cisterns were built inside the greenhouses in which to catch the rain-water which fell upon the roof, and many old-time gardeners to-day prefer the water secured in that way to any other for the purpose indicated, as they claim it is more soft and richer in the essential plant-

foods than is found in the water in general use, as from springs or wells or from water companies. There is no doubt as to the truth of this matter, but only in a very small greenhouse is such a method practicable. A cistern is sometimes used in conjunction with a more complete water supply, the water from which is held in reserve for special purposes.

A never failing supply is what must be secured else the result might prove disastrous. Out in the country, away from a regular water supply furnished by a company or municipality, a drilled or a driven well or a never failing spring or creek with a windmill or some other motive power whereby the water could be lifted to a raised tank or to a point on higher ground should be secured. The higher the tank or whatever the storage method may be the better, if the expense is not too great, because a greater pressure to aid in distributing the water is thereby secured; and a heavy water pressure is advantageous in the hands of a careful person watering the plants, because it aids in getting the watering done more quickly when haste is not a detriment. In the hands of a careless operator a high pressure is sometimes a disadvantage, because more water is likely to be given oftentimes to the plants than is good for them when said plants cannot use same to advantage, as during dark, cloudy or rainy weather or in a low temperature. A careful man will, however, regulate the water supply at the spigot by turning same on only half or even less as the necessity of occasion requires. A strong pressure is a boon in any greenhouse on a bright, warm day, when the water may be given freely, both at root and on branch, and many insects which are among the banes of plant life under glass are kept in check by the judicious use of a powerful force of water; this applies especially to what is known as the red spider, which will be treated under the head of insects, later.

A windmill was referred to as a good power to bring into use to lift the water to an elevation, but when this is used the storage capacity should be large enough for at least a two weeks' supply, though a two weeks' supply is very indefinite. As a guide, for a greenhouse 100 feet by 20 feet, 500 gallons a day on the average should be ample. It is surprising how much water our plants seem to need when the wind does not blow. In the months of August and September, we have very often noticed the wind is frequently not found working quite so faithfully as we would like it to do.

Other motive powers for pumping water besides wind, are steam and the various hot air engines, but the best water supply of all is, when obtainable, through some public works, as a municipality, borough, township, or by a private company.

The vast importance of the water supply will be realized when it has to be carried some distance on a bright, hot day. Personally, I

have carried water from a little brook, a pailful in each hand, fifty feet from the nearest point to the entrance to the first of four greenhouses one hundred feet long. This process of watering appears tedious and very hard work now in the light of our present up-to-date hose in hand operations. At another place I have dipped water out of a cistern until same was empty, when we had to carry it from a pond two hundred feet away, and in hot, dry weather as soon as we had finished watering the plants at one end of the greenhouses we had to begin and go all over them again, so much water did the large plants need. It is frequently necessary in hot,dry summer weather to water plants twice a day.

In some large establishments arrangements are made whereby the water is heated in the winter-time, to a temperature of 65 to 70 degrees, but when pumped direct from a well where the water is 56 degrees there is no necessity for the water to be heated. And the advisability of heating water before using on the plants has frequently been questioned, because the atmosphere in the greenhouse should be at least 70 degrees before watering over the leaves of the plants is undertaken, and under those conditions the water would be in a very few minutes the same temperature as the atmosphere.

DRAINAGE.

After the water question has been disposed of, drainage next suggests itself, and it is equally as important in greenhouse operations as it is upon the farm.

When solid beds are used in which to plant, or on a table or in a flower pot, it matters not which, we must feel reasonably certain that the drainage is ample. There is more necessity to look into this matter with some soils than there is in others; for instance, a clay soil will require more care in that respect than will that having a more porous character.

Some florists think they are gaining an advantage by using drain-tiles so close together beneath the beds as to touch each other. The manner in which this particular plan is carried out is as follows: First, the inside of the greenhouse in which this style of a drained bed is to be built must be carefully graded, not necessarily perfectly level, but on a uniform grade. The walks or alley-ways should be laid out at convenient intervals, and after the bed has been thoroughly firmed to avoid as far as possible the liability to settling, the drain-tiles are arranged across the bed, the open ends of the tiles to present a straight line and to remain open at the outer edge of what will be the bed proper and define the line of the walk.

When sole-tiles are used it is deemed advisable to place same with the sole side or bottom upward, which will thus present a better surface for shoveling, because more level, when the old soil is removed preparatory to bringing in fresh soil and new plants. When it is decided that the tiles are to be arranged with the soles upward, it will be found necessary, after the base of the bed has been made thoroughly firm, to scatter sand thereon or the finer particles of screened ashes or similar loose material in which to place the tiles to hold them in position until the job is completed.

A wall is then built six, eight or ten inches high, the base resting upon the ends of the drain tiles, said tiles to remain open as before advised; in this way complete drainage is not only secured, but what is believed to be of equal importance, the free passage of air through the drain-tiles will counteract the possibility of sourness in the soil, thus going a long way toward insuring the well doing of the plants.

The wall may be either of bricks, single, thick or concrete. Many retaining walls for solid beds are now being built with the last named material, which may be composed of coal ashes, gravel, sand and cement in proper proportions. Coal ashes are generally quite plentiful about a florist's establishment after he has started a short time, and I know of no better use to put them to than by building just such walls as above referred to, and as there are likely to be more of them in use in the future than there has been in the past, a few hints as to their construction will not be out of place at this time. Here is what the writer prepared for the columns of the American Florist a few years ago:

"It is ten or twelve years since I first commenced to experiment in making walls with concrete. My first efforts were made with iron ore sand (refuse from the iron mines) and cement, but this became rather too expensive, on account of the long and heavy haul in addition to the first cost of the material. Sand of all kinds in this part of the country is scarce. In 1892 it occurred to me that if we could use coal ashes as a base for this purpose how much cheaper and convenient it would be. (Our brethren in the natural gas belt may or may not appreciate that statement.) I made known my thoughts to a friend in the profession, in whose judgment I had explicit faith, and he said "It won't do, my boy, the acid in the ashes will destroy the effectiveness of the cement." This certainly was a stunner, and I cannot now recall how I overcame the effects of it and ventured to make the experiment with the tabooed material, but I summoned up sufficient courage to do so, and we now have six of our greenhouses fitted up with walls of this kind, and they are apparently all right up to the present writing.

"We have never used any other but ashes from hard coal—anthracite—but believe the ashes from soft or bituminous coal could be

used with almost if not quite as satisfactory results. The greatest trouble we find is in preparing the boards into which the materials, when properly mixed and ready for use, are deposited in order to make the wall. If we would have a straight and mechanical looking job when completed, the boards must be braced thoroughly by driving in stout stakes alongside at frequent intervals and then nailing together temporarily though securely at the top to keep them from spreading, which they surely will do when the wet and heavy concrete is shoveled inside the casings. There would be much saving of labor if two-inch or three-inch planks were used instead of inch-thick boards to form the frame work into which the material is dumped, because they would remain in position better and with fewer stakes.

"Not until all the moulds, as we may term them, in which the walls are to be cast are ready should the concrete be mixed, and then only such a quantity as can be used in half an hour. When, as above indicated, everything is quite ready to begin operations, we have a board or rather a number of boards nailed together, eight or ten feet square, with the joints as tight as it is possible to make them, or some of the cement will wash through with the water, then we proceed to mix the ashes and cement together, taking six or seven parts of the former to one of the latter, of which we find the better brands of Portland cement the most economical. These materials should be thoroughly mixed by turning three or four times, and should be done while they are quite dry, before any water is applied at all, after which water may be brought into use, and when every particle is thoroughly moist without being too wet it is ready to be applied to where the walls are to be built, and with reasonable activity, employing as many men as can be used to advantage without being in each other's way; this part of the operation is a short one.

"The concrete should be pounded with a rammer gently though sufficiently until it has filled all the spaces completely, and topped off evenly to the level of the boards or planks. When as much of this part of the operation has been done nearing the end of the day or job, cement and sand should be thoroughly mixed, one part of the former to two of the latter, and mixed dry as before recommended for the ashes and cement, and also watered in the same way; this must be used to put the finishing touch to what will be the top of the wall, and with one man with a shovel to drop it at intervals along the top of the wall and another with a bricklayer's or plasterer's trowel—the latter being the most handy—a smooth face is attained that will be one of the most important and essential parts of the whole operation, for it is this which keeps the wall that is made of ashes and cement from crumbling; it certainly would crumble if the sand and cement were not applied, and at a time before the wall

proper has had time to dry too much. A mechanical and smooth job may be made of the top of the wall if the operator will have a whitewash brush and a bucket of water convenient so as to apply it occasionally when the smoothing process is going on by the man with the rowel; a little water and the trowel following until a smooth surface is the result. If the "topping" part of the work just referred to is not done promptly, much time is lost in the completion of the job.

"After a few days—according to the weather and the time it takes to dry—the boards on the sides may be removed, and this, of course, must be done carefully; and these sides should receive a coat of cement in which sand has been mixed, in the same proportions as recommended for the top of the wall. Owing to the coarseness of the ashes used here, it is found when the boards are removed that although a more or less uniform or straight surface is presented, enough interstices will remain to give the sanded cement a good hold on the wall when plastered and, when thoroughly dry, the wall will be found as strong as though having been built of bricks, and at very much less cost.

"As to the cost of the materials, that depends upon what part of the country those who desire to build walls for solid beds in greenhouses are living in. In the natural gas region, ashes, which are so plentiful in other parts of the country, are at such a premium that they are quite out of the question in this connection, but in those sections probably, or at least possibly, sand or gravel or broken stone may be had for the hauling or at such a trifling cost that the same results may be obtained as low or at so little or no more cost that the difference is hardly worth considering; besides, it goes without saying that a wall made from sharp sand or gravel or broken stone, with cement in correct proportions is very much more substantial than can possibly be made with refuse ashes, though I must say that I have yet to find that a break has occurred in the walls built as per above method, excepting when some accident happened that no wall could possibly resist.

"I have one house fitted up with this class of wall on which a a table is built so as to get an idea if possible on which plan roses bloom the best, but so far I am not able to decide. There are so many contingencies arising in the growing of cut flowers during a whole winter season that it is very difficult to decide which is the better plan. One thing we are sure about and that is, a solid bed is easier to empty and easier to fill than is a table, and no time is lost as in the repairing of the tables. Other matters which must be taken into consideration, whether solid beds or tables are the better, is the nature of the soil in which the plants are to be grown, and above all, thorough and proper drainage must be secured; if not naturally, then it must be made artificially."

In the building of tables or stages upon which to grow roses, carnations or other plants, the boards used for forming the bottom of said tables are usually six inches wide and are placed from a half-inch to three-quarters of an inch apart, and over the bottom of the stable coarse manure, straw or material of like character is spread to keep the soil from trickling through and also to aid in securing the necessary drainage. Drainage in pots, "crocking," is provided for by placing broken pots, oyster shells or coarse coal ashes at the bottom. Any pot smaller than that known as a two and a half inch pot is rarely or never "crocked."

To go back to the drainage of the solid beds again. Some soils are so well drained naturally that there is no necessity of going to the trouble or expense of furnishing any other form of drainage. Generally speaking, however, it is believed to be safer to furnish some sort of drainage. Drain-tiles are sometimes laid in the length of the bed, and the deeper they are laid in the earth the larger the area which a given line of pipe will drain. Some florists lay two lines of tile the length of the house in each bed, only as deep as the natural grade would be, and these ends are left open and project through and flush with the outer edge of the retaining walls, as much to aerate the soil as to drain same from surplus water. Coarse coal ashes, broken bricks, stones or similar rough material is frequently used at the bottom of bed for the same purpose.

Sub-irrigation is being experimented with to some extent, but so far a cheap method of constructing a bed where sub-irrigation could be practiced to advantage has not yet been adopted to any extent. It promises well, I am inclined to think, but just the right plan of operation has not so far been hit upon.

ASPECT.

There is some difference of opinion as to the proper aspect of a greenhouse to be used exclusively for the production of cut flowers in winter, the consensus of opinion favoring a position a few points east of south. This aspect favors the early morning sun getting in his good work, which is considered the most life-giving, consequently of the greatest value and best not for plants alone but all animated nature.

When a greenhouse is built in which to grow Palms, Ferns and Smilax and other classes of plants which are grown for their foliage alone, it makes little or no difference which aspect the greenhouse occupies. Palms assume a deeper green and develop equally as satisfactorily if they are not given too much sun at any stage of their existence. In Belguim, where many Palms and other foliage plants

are grown for the London, Paris, Berlin, Vienna and St. Petersburg markets, boards are largely used in conjunction with glass in the construction of roofs of greenhouses in that country. By the use of boards there is a great saving, not only in the construction of a greenhouse, but in the heating of same in the winter season. A greenhouse with a roof built of boards, or partly so, will retain the heat much longer than will one covered wholly with glass, and the desired temperature can be maintained at much less cost for fuel. We are assured by those who have seen the Palms growing under conditions as above stated, that no plants could be more luxuriant or healthy. At the price glass was selling in September (1901), namely $7.28 per box of fifty square feet, a great saving could be effected in this country by the method referred to. Glass fluctuated very much last year; for instance, in September, $7.28 was the price per box of fifty square feet, whereas, in November, the same quality of glass could be bought for $4.55, and twenty years ago $2.00 per box was about the price.

It will be understood that what is said here is merely suggestive, that much latitude is allowed in the selection of a site for a greenhouse establishment, according to what is to be grown and the available ground to be used; and also in the selection of the material to be used in the building, many believing that as much iron or steel as possible should be used so as to have them as nearly indestructible as such structures can possibly be made.

HEATING.

After the water supply has been determined upon and the question of drainage and aspect duly considered, another serious matter to occupy the attention of those desiring to go into the greenhouse business, is the different methods of heating, because, generally speaking, quite early in the operation a hole in the ground has to be dug, known by the old-school gardener as a "stoke-hole." Though some of the very largest and up-to-date commercial concerns, where steam is used as the heating medium, do not advocate digging a hole in the ground at all, but by placing the boiler or boilers at the lowest point naturally, according to the lay of the land, and by employing a small, though a separate and independent steam-boiler, which is so constructed as to work automatically and thus pump the condensed water back to the boiler. In a small way, however, that plan of operation would seem to be out of the question, the water returning by gravitation being the most practical.

Generally speaking for small establishments, it is better to dig a hole, whether the heating be done by steam, hot water, or the old-

fashioned flue, for a better draft is thereby secured, which is a very necessary accessory in the keeping up a good fire to heat to the desired temperature; and, besides, a cellar is a great convenience in which to store, when possible, the winter's supply of coal.

There are several methods of heating, but three only need be considered at this time. What is known as the old flue system, which is practically a furnace with the chimney running nearly horizontally with a gentle rise to the further end and the whole length of the greenhouse and sometimes back again, the heat being given off in transit, and thereby warming the house. This was the first method of warming greenhouses, and when only one greenhouse to be taken care of this is certainly the cheapest plan of all; and where a variety of plants, coming from the different quarters of the globe, are to be grown this plan offers more variations of temperature to suit same in a given length of house than any other, that is to say, without special preparations are made with hot water or steam with that end in view. We, however, do not recommend the flue system for heating greenhouses, as it has some grave disadvantages, the principal one of which is the liability of deleterious gases escaping from the flue into the greenhouse, and plant-life suffers in consequence, so much so that crops have been known to be total failures by the damage done to the leaves and flowers.

Hot water as a heating medium is perhaps the very best method of heating a greenhouse establishment in a small way that can be devised when the structures occupy not over 25,000 square feet to heat, because requiring less frequent attention than does steam. The main advantage of hot water over steam is, that there is not the same necessity of having a fireman up all night to attend to the fires as when hot water is used, because so long as there is a handful of fire in the furnace there is sure to be some heat in the water; whereas, when steam is used, just so soon as the fire is not hot enough to make steam, then the pipes immediately become cold and on a freezing night damage is likely to result, either by the frost entering the greenhouses and killing the plants outright, or by so chilling them that many weeks might elapse before they fully recovered.

When, however, a greenhouse establishment has twenty-five thousand feet or over, it is better to use steam and employ a night fireman, and the right kind of a man who is willing to do other work during the night, especially in mild weather, can find lots of little jobs, such as washing flower pots, putting in cuttings, and sometimes even potting could be done. Great assistance can be rendered by the nightman in the early morning by assisting to cut and pack the flowers for market, which in establishments of any pretensions, are shipped at least once and frequently oftener, every working day in the year and sometimes on Sundays. Flowers, being perishable, the quicker they are disposed of the better.

The night fireman must watch the temperature closely. Many establishments are fitted up with electric thermostats to warn the proprietor or the manager or foreman when the temperature is too low or too high; this fact keeps many firemen on the alert when they would otherwise be indifferent and become careless. Self-registering maximum and minimum thermometers are sometimes used for the same purpose securely locked in a case so that they cannot be tampered with. There are several details to be attended to personally by the fireman besides shoveling on coal and keeping up steam. A pipe has to be "shut off" at this house, or a "crack of air" admitted through the medium of the ventilating apparatus, or an additional pipe "turned on" in another house in order to keep the atmosphere at the desired temperature. As before referred to, there is an automatic ventilating apparatus in use which is giving general satisfaction.

As to the fuel, whether it is best to use anthracite or bituminous coal, crude oil or natural gas must be determined by individuals for themselves. Natural gas, when same may be depended upon in unlimited supply, would be my own individual preference. No shoveling on coal, no cleaning of the fires, no ashes to take out. What a boon!

In and near to Philadelphia there is quite a lot of what is called "buckwheat" anthracite or hard coal used. This buckwheat coal, however, is only used where steam is the heating medium. Some others within the city limits use coke, a by-product in the manufacture of illuminating gas, while still others are using bituminous or soft coal; the latter has its decided disadvantages on account of the dense smoke and the resultant "blacks," entering the greenhouses through the ventilators which are very damaging to all classes of flowers, especially the whites and other delicate tints, and by falling upon the glass more or less shade is produced, something to be avoided in the growing of flowers in the winter season when every ray of sunlight should be allowed to come through the glass unobstructed.

When a battery of boilers is arranged conveniently in a central position or as nearly so as possible, and the greenhouses radiate therefrom, one man can attend to a much larger place and better than he otherwise could. With all essential conveniences for a night man, he can attend to 75,000 square feet of glass in ordinary weather, but when severely cold, an extra man would have to be brought in to assist. When it is impracticable to put in an automatic ventilating apparatus, and the place is large enough to warrant the expense of an additional man to look after the temperature of the houses, then the fireman may remain at the boilers all the time and have nothing to do or think about except to keep up the necessary steam pressure to assure a complete circulation of heat to the remotest corner of the establishment.

As a rule, with the requisite amount of executive ability centered in the guiding head, the larger the establishment the easier it is managed and naturally the more profits result.

We hear of an automatic stoker—a machine to coal the fire when needed. I have not seen it in operation, but there is no doubt about its being successfully done in a few large establishments. With such a machine and an automatic ventilating apparatus, two of the most important matters are provided for. All that would be necessary in such a place with those contrivances would be a night watchman, with the day men located conveniently to be on call in case of accident during the night, because in many large establishments there are thousands of dollars worth at the mercy of the elements in case of a breakdown in the heating apparatus or the breaking of glass.

The very best, because offering the least trouble and expense after the first cost, that I have heard of is in an establishment located at Helena, Montana, which is incorporated under the name of "State Nursery Company," the greenhouse department of which is heated by natural hot water. The hot water is conducted through the greenhouses in pipes, as is done when a boiler is used, excepting that no provisions are made for the water to return, it flows on after it has done its duty, apparently going to waste. The springs from which the water is taken are about half a mile away from the greenhouses, and the water is conducted in a wooden pipe under ground and has a fall of one hundred feet, which registers about thirty pounds pressure. The temperature of the water is 130 degrees when it reaches the greenhouses so that it takes more lineal feet of pipes to insure the atmosphere in the greenhouses being raised to the desired temperature than it does when the heating is done by the ordinary methods of steam or hot water as practiced in Pennsylvania. This item of information is introduced here incidentally to indicate the advantages that some florists have over others, especially out in far away Montana when the question of heating is under consideration.

DISEASES.

Mildew—so called probably on account of the mealy-like substance which is spread over the leaves of the plants affected—is the most common disease which affects roses and yet one of the easiest controlled. The very best way is to use preventives, which is done by using flower of sulphur mixed with about its equal in bulk with air-

slacked lime, which is distributed with bellows made for the purpose into the atmosphere of the greenhouse to be operated upon. This effective mixture above described has been in use for some time, and its beneficial results were found out by accident. Florists and others who use sulphur in large quantities buy it by the barrel. During a rainy spell, which, by the way, is a good time to keep the mildew-killer active, the sulphur works sluggishly, on account, I presume, of its possible affinity for moisture; so in order to make it distribute more freely, some air-slacked lime, passed through a fine sieve, was added in about equal its bulk to the sulphur. This was found to be equally as effective as sulphur alone and more economical.

Many a careless hand wastes much of this material. The best way to apply it because the most effective and economical way, is to use the bellows referred to, fill same with the mixture and with the outlet pointing upwards and the operator working the bellows and walking backwards, the atmosphere of the structure will become well filled with this mildew antidote, and in settling ,which it will do gradually, it does so quite evenly and not unsightly as it is likely to do if the spout of the bellows is allowed to point downwards and the material irregularly distributed as is too often done. Another preventive for mildew, is to mix sulphur with linseed-oil to the consistency of a paste and apply with a brush to the heating pipes. The fumes of the sulphur are by this method believed to kill the fungous germs which are always more or less present in the atmosphere, awaiting favorable conditions to develop.

"Black spot," *actinonema rosae*, among diseases is the worst enemy the rose has to contend with, and this applies to those grown both indoors and outdoors, especially among that class of roses known as the "Hybrid Tea," which has for its parentage the Hybrid Remontant, or June rose, on the one side and the Tea-scented rose —a native of China—on the other. The Tea rose gets its title from a peculiar tea-like fragrance and not because it resembles tea in any other way. The LaFrance and Meteor, and possibly the celebrated American Beauty, belong to the Hybrid Tea class.

The American Beauty appears to be the most susceptible of all roses grown under glass to black spot, and when a bad case develops it is very, very hard to get rid of. Bordeaux mixture, the same as recommended for fruit trees, is said to cure it, also copperdine; but I must confess that I have never yet found much if any benefit from the use of either. Potassium sulphide is also recommended. Any of the above might be used systematically as a prevention, and doubtless with more or less gratifying results.

It has been found, in practice, that no matter how badly affected a rose may be with "spot," at the end of the cut flower season, say the latter end of June or early in July, if all the branches are cut close

from the plants about six inches to three inches from the base of the plant, these same plants, when they start to make a new growth, will grow without the slightest sign of black spot, and it is not until the month of September, when the growth made is from three or four feet high and densely clothed with leaves, that signs of this dread disease reappears; and then the cause is no doubt on account of some indifferent treatment given the rose, or some climatic conditions favoring the development of the fungus that science has not yet been able to detect in time to effectively stop, and it is found that the more luxuriant are the plants in the autumn months the more liable are they to this disease.

The plan followed and the safest, is to pick off and destroy by fire every affected leaf as soon as seen. If the plants can be safely carried through the late summer and early fall months without showing signs of black-spot, the danger is not so great, especially after the heating in the rose-houses has commenced, for little or no trouble will be experienced with it during the winter until firing is stopped in the spring, when it is again liable to appear at any time. And when it does make its appearance at the season of the year indicated, it spreads with great rapidity, being very difficult at that season of the year to combat. It is believed that the dew or any form of moisture upon the leaves and in the atmosphere favor the propagation and development of these disease germs, and as water must be directly applied vigorously to the underside of the leaf where that troublesome plant pest, the insect-mite known as red spider, takes refuge for self-protection, and as the water remedy recommended which is the only known method to dislodge him adds greatly to the moisture produced, it is readily realized how difficult it is to give water sufficient for all the needs of the plants and yet not enough to encourage the black spot scourge.

There are other diseases to which the rose is subject, but mildew and black spot are the most prevalent and those which give the most trouble and anxiety.

Carnations when grown under glass are liable to have quite a number of diseases. The one about which so much was said and which caused so much anxiety some ten years or so ago, was the so-called Rust (*Uromyces caryophyllinus*), but it does not possess the same terrors as it did at that time. In appearance it resembles smut in grain, the difference being that the black or dark brown dust-like material appears on the upper surface of the leaf and looks as though it were a bursted blister.

One which has caused, and is causing some anxiety to-day, is what was at one time known as *Bacteriosis*, now known under the scientific name of *Stigmonose*, and is the result of punctures by insects which are liable to infest Carnations. The insects responsible for this "puncture disease," are the most common of all plant-lice, namely,

the green fly, or aphides, and to a lesser extent, thrips and red spider. The punctures made by these insects make it possible for the disease under consideration to develop. It goes without saying that to avoid the Stigmonose is to keep the plants free from insects. And the rust, strange as it may appear, is entirely gotten rid of by growing the plants under glass both winter and summer.

The present day carnations are a development from the hardy Dianthus Caroyphyllus of Europe, and some of the closely related varieties to-day will live out all winter in some parts of America when grown in a favored location. That the rust on carnation plants could be gotten rid of in America by growing same under glass, which is a hotter and dryer climate than is that of Europe, does seem difficult to realize, yet such has proven to be the case. It is the result of what is termed an "accidental discovery." The writer hereof, before the American Carnation Society at its convention held in Boston a few years ago, along the lines under consideration, said:

"Having a seedling carnation that was good enough to send out as a novelty the following spring, and in order to get up as large a stock as possible I kept on rooting the cuttings until quite late in the spring or early summer. It was so late, in fact, and the weather so dry that those plants remained in thumb pots all summer under glass instead of being planted outdoors. After the general collection of carnations had been lifted in the fall, this particular seedling showed unmistakable evidences of being affected with the much dreaded rust. As soon as possible all the affected leaves were picked off and distroyed; but when the job was completed the plants appeared to be planted too far apart, so much foilage had been removed, and in order to fill up the spaces we made use of the small plants which were rooted late and had remained in thumb pots under glass all summer. They were planted between the rows or lines of the affected plants, and, strange as it may appear, the unaffected little plants on each side of those were never affected by the rust during the whole season, while the older plants never recovered from the effects of the disease. At that time the rust had not created quite such a profound impression upon growers as it did later. This point is introduced in order to show how it came that I decided to try the Buttercup Carnation under glass all summer. I reasoned in this way, that if one disease could be combated by this treatment, why could not other diseases be combated by the same treatment, and I am pleased to be able to say that the results have been eminently satisfactory. And further, I believe that we will find that some of the choice varieties, if we wish to get the very best results from them, will have to be grown under glass all summer."

Since that time a modification of the cultivation of carnations has taken place. Instead of leaving the plants growing out of doors, as in the old way, to the end of September or sometimes even as late as

immediately before damaging frost is expected, which varies according to location (in the vicinity of Philadelphia, however, it is about the middle of October, and some seasons it is a few days earlier and some a few days later than the time mentioned), now, in these days the first week in August is considered by a number of the most successful Carnation specialists to be the best time, and the date named for lifting is about the season when Carnations begin to make their most rapid and vigorous growth outdoors when the nights become cooler with more moisture in the atmosphere from the dews and fall rains. The wisdom of the course now pursued is very readily understood when we consider the greater length of time the plants are growing outdoors, the larger and more succulent they naturally become and the more violent the shock from the breaking of the roots when they were lifted, the only wonder now is that such a more rational method of treatment had not been practiced earlier. The plants not being so gross in growth at the earlier date, they are not injured nearly so much in the transplanting, consequently are not so susceptible to any of the diseases to which Carnations are liable; especially is this the case when the plants are in a weakened condition from the effects of the greater disturbance of the roots when transplanting under the older practice.

The various fungicides are no doubt excellent as preventives, and should be systematically used for that purpose, but when disease does show itself the affected parts should be immediately removed and destroyed by fire.

Stem Rot, which its name implies, is the plant rotting off just above the ground line. There is no positive remedy for this disease. To-day a plant affected with this disease may to all outward appearances be enjoying the best of health, and to-morrow it will be withered and dead. This malady among Carnations, according to Professor Albert F. Woods, Chief of the Division of Vegetable Physiology and Pathology of the United States Department of Agriculture, at the meeting of the American Carnation Society, held at Baltimore last year, stated that it is brought about through two distinct kinds of fungi. One which is known scientifically as *Rhizoctonia*, or wet rot, develops most in acid soils, especially where there is much decaying organic matter. The *Fusarium* is the scientific name of the other, or dry rot, and is not so prevalent as is the former among Carnations. Lime is found to be an excellent preventive when used on the soil for the former. One grower secured excellent results when he used between fifty and sixty bushels to the acre to combat Stem Rot. The second, or dry-rot fungus, grows best in a soil slightly alkaline. It is said to be closely related to the fungus which is almost driving out the cotton industry in both North and South Carolina. There are hundreds of acres of land where cotton cannot be grown any more where said fungus is present. This fungus

has been found to retain its vitality for five years. No fungicides have been found strong enough to entirely rid the soil of its presence, as there is always enough left in the soil to start the disease on the next cotton crop. For greenhouse purposes the soil may be sterilized with steam at 130 to 140 pounds pressure when every germ of all fungi would be killed, and weed-seeds also, which would be a decided advantage. Some growers have thought that there is a possibility of the soil losing some of its fertility when sterilized, but the Professor stated that in some experiments with sterilizing soil for Violets no injury at all was apparent, instead the Violet plants grew entirely too rapidly. It is of course, for greenhouse purposes, that the sterilizing of soil is at all practicable. Some of our expert rose growers make a practice of systematically sterilizing all the soil used in their rose-growing operations, and they are prepared to prove that it pays to do so. Some soils, it is believed, contain more nematodes, or eel worms, than do others, and it is for the purpose of killing this troublesome little microscopic fellow in the soil that sterilizing is practiced for roses.

A disease called "Black Rust," but entirely distinct from that affecting Carnations, affects some greenhouse plants, Heliotrope and Verbenas, especially. The leaves affected show dark blotches, which in bad cases causes the leaves to become more or less crippled. Black Rust is believed to be caused by one of the mite-insects, which require a strong microscope to detect. There is hardly any cure for this disease when in an advanced stage, and it is better to destroy the plants so affected entirely and start anew with clean, healthy stock. Stunted, half starved plants are the first, and generally the only ones, to take this disease, so that to avoid it, generous treatment is the one great thing needful to keep the plants healthy.

There are other diseases affecting plants, but those mentioned are the most troublesome, and in order to be sure that everything is being done that can be to avoid diseases in plants, cleanliness in every department in the greenhouse must be the watchword, and ought to be rigidly enforced; and it must be here emphasized that the various fungicides should only be depended upon as preventives, and not cures.

INSECTS.

The insect which bothers plant-life in greenhouses most, or in the greatest number, and at the same time the easiest to get rid of, is the "green fly," or plant-louse, one of the numerous species of aphis which has the power of reproduction to an extraordinary degree—too prolific almost to be fully realized.

The most common plan in practice towards destroying them is by fumigation, which means, in this case, to burn tobacco stems, which may be obtained in bales from the seed stores which keep same in stock for the convenience of customers.

The process of burning is as follows: A small bunch of dry paper or shavings, with a few dry stems to give the same a start, is placed at the bottom of a can made for the purpose, with a perforated base to cause the requisite draft, then the stems, with which the can is filled, and which are expected to do the effective plant-lice killing, before the light is applied, should be a trifle dampened; by this means flaming is avoided, which should never be allowed, as the hot flame with the deleterious gases generated under those conditions are likely to do serious injury to many tender plants which may be within the structure operated upon, as Heliotrope, Mignonette, and some other plants. When the tobacco stems are not too damp to burn, yet too damp to flame, they are just in the proper condition to produce the smoke—the nicotine fumes—which suffocates our plant-enemy, the green fly.

Tobacco dust, when not too fine, may be used also for fumigating purposes, and is put into operation by placing the material upon plain paper in a perfectly dry spot on the floor of the greenhouse, and with a few drops of petroleum ("coal-oil") at one end of the pile of tobacco dust, then with a lighted match, touch the spot whereon are the drops of oil, when it may then be allowed to burn until entirely consumed, as no harm to the plants will result.

Paper steeped in a solution of saltpetre (potassium nitrate) and dried is also used upon which to place tobacco dust and burn. In this case no petroleum oil is needed; by touching the prepared paper with a light the combustion of both tobacco and paper is complete, and without flame.

There is also what is known as Aphis Punk on the market, a peculiarly prepared paper, which is hung on wire in convenient places in the greenhouse, and when lighted, is allowed to burn. This must not be allowed to flame either, or similar damage before referred to is likely to result.

There are also a variety of liquids much in use nowadays, where nicotine or the extract of tobacco forms the base and principal part of this class of insecticides. Sometimes these liquids when reduced to the proper degree of solution are applied directly to the plants troubled with insects, by spraying. Another plan frequently in use is when the liquid is placed in some convenient vessel and hot irons are dropped therein, filling the atmosphere full of the insect death dealing vapor. Some of the more advanced florists are using an evaporating pan which is attached to the heating pipes; the liquid is placed in the pans and in due course is evaporated into the at-

mosphere. When these have been used, no other means of green fly extermination is thought of, so thoroughly practical have they proven to be.

A spirit lamp is also used, attached to the bottom of a small vessel containing a highly concentrated insecticide, and when the lamp is burning the liquid is vaporizing, and in this and other methods of vaporizing, doing away with the clumsy methods of burning the tobacco stems. The vaporizing of the different liquids is a step in the right direction, being equally as effective and far less troublesome and more agreeable for the operator than the old way.

In regard to the pans attached to the one and a quarter inch steam pipes, it has been demonstrated that when in use in the palm houses, and the pans have been filled with a tobacco extract regularly every night, neither mealy bugs nor scale insects will find a resting place or will be in any way troublesome. This applies principally when the young Palms are raised from seed at an establishment, which is equipped with the evaporating pans and none of the insects mentioned are brought there from a distance with other plants.

Roses and Carnations under glass are rarely or never bothered with either scale insects or mealy bugs, but Palms and Ferns are, and when once these pests obtain a foothold they are hard indeed to get rid of. Tobacco water sprayed on the Palms and Ferns twice each week systematically and intelligently applied, will rid the plants of said insects entirely. Many florists and gardeners, when they find their efforts are not rewarded sufficiently after the first few applications by a complete extermination, become impatient and disheartened and abandon the good work; when so easily discouraged all the work done up to that time will have gone for naught and the time and material will be as good as wasted.

Sometimes when an attack of either of the two insects mentioned develops, or in fact any insect, it is often best to secure a soft piece of sponge and with soapy, warm or hot water—but it must not be hotter than 125 degrees or there is a liability of the leaves becoming damaged—the insects are "sponged" carefully off the leaves. Hot water up to the point above mentioned has been found to kill many insects, and that may be considered the cheapest insecticide obtainable.

Red spider (*Tetranychus telarius*) among insects, is the most persistent foe, and the hardest to conquer, when once well established, the greenhouse man has to fight, so that he must exercise the greatest care when introducing new varieties into his collection, to see that they are entirely free from all insect life before being brought into contact with his own collection. If that method is generally followed it will go a long way towards banishing injurious insects from our greenhouses.

Because it has been observed that the little mite of an insect, known to gardeners and florists and all those who grow plants and flowers under glass as the "red spider," appears to increase and multiply more rapidly in the most dry and hottest part of the greenhouse, the conclusion has been reached and the rash statement made that moisture in the atmosphere will effectually banish him. Nothing could be farther from the truth. When the only method of heating greenhouses known was the flue system, which was in vogue hundreds of years ago probably, and which, owing to its primitive methods of distributing the heat, that end or part of the greenhouse where the furnace was located was the hottest and dryest, and that is where the spider flourished and was doing the most damage; and because at the end farthest from the fire there were less of the insects, the writers of those days were led to make the assertion that a moisture-laden atmosphere was death to the Red Spider, and many writers since have perpetuated the same old story. Much that passes for scientific knowledge too often is not the result of observation and investigation, but is merely compilation.

Professor Cranefield is a keen investigator, and the following results of his recent investigations are taken from the columns of the American Florist:

"Is it necessary to maintain a moist atmosphere in the greenhouse in order to keep down the red spider? Will not the spider thrive as well in a moist air as in a drier air? According to the evidence of experienced florists the spider is most destructive to Carnations when the temperature of the houses is maintained at 50 degrees or above at night and 70 degrees to 75 degrees in the daytime, whether the air be moist or dry. When the houses are maintained at 38 degrees to 45 degrees at night and 10 degrees higher in the daytime the spider is rarely troublesome, regardless of the moisture in the air. Roses are affected more or less according to the temperature maintained, the higher the temperature the more abundant the spider, regardless of the moisture in the air. Palm and Fern houses are usually free from spider, not on account of the moisture in the air, but because of the almost daily syringing the plants receive, thus destroying the spider by force, and secondarily, of course, the fact that these species of plants are less susceptible to attack by the spider.

"During the protracted heat and drougth of the past summer in southern Wisconsin many species of trees and flowering plants, notably Plums and Asters, were severely injured, in some cases killed outright by the red spider. This condition was no doubt largely, if not wholly, due to the lack of rain, the lack of the impact of rain drops on the leaves and consequent drowning of the insects rather than the lack of moisture in the air. Evidence in support of this

theory was abundant in gardens where the plants were frequently and thoroughly syringed.

"Referring again to greenhouse work, in former articles on this subject, I have noted the experiments in the plant houses at the Wisconsin Experiment Station, where live steam was allowed to escape into the houses for periods ranging from eight to twenty-four hours, completely filling the houses and without causing any injury or apparent inconvenience to the red spiders.

"In order to obtain more evidence on the subject an experiment was conducted last March in one of our plant houses as follows: A closed frame, sides, roof and ends glass, was placed on a side bench over steam pipes. In this frame was placed a variety of plants in pots, including Clothilde Soupert roses, Coleus, Heliotrope, Tomato and other plants. The plants had all been carefully syringed for several days and were all apparently free from spider when placed in the frame. The air was kept moist almost to the point of saturation for several days with no bad results to the plants.

"At the end of a week red spider was introduced by dropping on the plants several badly infested leaves from a rose plant growing in another house. Now, according to the commonly accepted opinion, the excessive moisture in the air in this frame should have prevented any increase of the spider. The actual results, however, were wholly different, the plants becoming quickly infested and at the end of three weeks were wholly destroyed by countless millions of red spiders. Both temperature and moisture were maintained at a high point throughout the experiment, the glass sides of the frame and the foliage of the plants being almost constantly moist.

"While these experiments do not furnish conclusive evidence that red spider will thrive in a moist atmosphere there is in it 'food for thought.' Is it not true that the spider is kept in check wholly by the force used in syringing? Does any gain result from the daily wetting down of walks, etc., practiced by greenhousemen?"

Sulphur in its different forms is believed to bother red spider more than any other one thing. A combination insecticide, known as Sulpho-Tobacco Soap, which, as its title implies, is made of sulphur, tobacco extract and soap, I have found about the best and most effective in stopping the ravages of this little pest; but to do any good it must be used nearly daily among plants when badly affected if we would have it produce the desired effect and restore our plants to health and vigor again.

A good force of water, say with at least thirty-five pounds pressure, applied directly beneath the leaves where red spider finds its resting and working place will be found to keep it from making much headway. The great disadvantage we are laboring under, especially

in the dark, dull days of winter, is that we dare not use water on the foliage of roses too freely, else we run great risks of giving the plants more water than they need, especially on the leaves, and in that way encourage diseases that are even worse if possible than is the red spider.

SOIL.

Every tiller of the soil knows the importance of Mother Earth well tilled no matter what the crop. Any good, loamy soil properly prepared for a corn or any other farm crop, when the tiller is reasonably satisfied that it could not be improved upon, is all right to be used for nearly all plants grown in a greenhouse. If, however, the desire is to go to a little more trouble, then a few loads of sod from an old pasture should be secured and carefully piled up with some rich cow manure and ground bone and wood ashes, the two latter ingredients weight for weight in about equal proportions. The cow manure will give all the elements of plant food, and the bone meal will give some ammonia and phosphoric acid, and the wood-ashes some potash additional and some lime. Place the sod grass side together and a layer of manure occasionally, about one load of manure to five loads of sod or good loam will be in about the right proportions, and an occasional sprinkling of the bone and wood-ashes, about one hundred pounds of each to every five loads of sod would make an excellent compost. If this pile is put up in the fall, allow it to remain until the weather commences to get warm in the spring, then turn the pile over, taking care to break up the lumps and mix well the whole together.

Soil for plants to be grown in a greenhouse should not be handled when it is wet, no more than it should for a farm crop. When preparing soil for large operations, the plan is to manure heavily a piece of old sod if possible with cow manure in the fall, and just as soon as the grass begins to grow, and before it grows too long so that it will plow down nicely and cover easily, it should be plowed without further delay, then a heavy roller should be passed over the soil a few times to compress same; then use the drag harrow freely, in this way most of the little holes will be filled and an almost level surface obtained. Then a good guaranteed quality of bone should be evenly distributed over the whole, and the ground harrowed

thoroughly again a few times to mix the bone and upper surface of the soil well together. That done, then apply about the same weight of good, dry, unleached wood ashes in the same way. These should also be well mixed by harrowing. The plot is kept continually stirred by harrowing, especially when sufficiently dry after rain, and the harrowing answers another purpose, that of keeping down the weeds. This soil is frequently taken into the greenhouses in from three weeks to a month after plowing, but never before three weeks, because serious damage ensues when taken in sooner.

Crimson clover is being used to furnish humus and nitrogen in some establishments with satisfactory results. Cow peas also are being used to plow under for soil for greenhouse purposes. It is a safe rule to go by, that a soil on a farm that will grow first-class crops is a safe soil to use in greenhouses. Sometimes it is deemed wise when the soil is of a heavy clay nature to add road or bank sand to make the soil more porous. Coal ashes, when the rough cinders have been screened out, are frequently used for the same purpose, and with no bad effects.

For Ferns, soil from the woods, known among gardeners as leaf-mold, is often used with excellent results. Muck from a low lying meadow, after it has been piled up on higher ground where the frost, sun and wind have a chance at it for several months to sweeten same, is often used mixed with equal parts of clayey loam to advantage, though muck is not recommended for roses. Air-slacked lime is also mixed with good results with this class of soil to correct possible acidity before it is used for greenhouse plants.

PROPAGATING.

The most natural way to increase most plants is by seeds, and numerous occupants of the greenhouse are increased in that way; but there are other ways of multiplying the number of a given variety, one of the commonest is by "cuttings" or "slips," and this perhaps is the most fascinating part of a fascinating occupation. To take a sprig of a plant and insert it in soil or sand and in three or four weeks' time have tiny roots emitted from the base indicates success and means an awakening of the senses to both young and

old, and the sensation incidental to the first attempt in propagating plants in this way is more readily imagined than described.

"Grafting" to increase some varieties of plants is frequently resorted to under glass, especially does this apply to roses. There is in some soils with some varieties of roses a decided advantage in using "grafted" plants, and among the stocks used giving the most general satisfaction is one introduced into France and England from Italy half a century or so ago, known as the "Manetti" stock. The varieties of roses which show a marked improvement when grafted are what is known as the "Mermet" family, which consists of the Bride, a white sport from Mlle. Catherine Mermet before referred to, and Bridesmaid, another sport from the same variety which produces darker and brighter pink colored flowers than does the variety from which it sprung. Among the advantages claimed to be gained by grafting by many growers of roses for cut flowers in winter is, that the plants produce more flowers and flowers of better quality than they do on their own roots.

The varieties of roses referred to form roots very readily, as cuttings, when given the necessary care which consists of never allowing the sand in which the cuttings are inserted—which is generally known as a propagating bed—to become dry, nor to allow the cuttings to wilt by allowing them to be exposed unnecessarily long to the influence of the sun. Judicious shading of cuttings is at all times recommended, and a movable and not a permanent shading is considered the better, for if a cutting is rooted under a dense shade, the young plants, rooted under those conditions, are liable to have their constitutions impaired. Consequently material to be used as shading should only be placed over the cuttings when the sun's influence becomes too strong. Newspaper is very frequently used with which to break the fierce rays of the sun from the cuttings and is as effective as anything that can be used. If cuttings are once allowed to become dry and wilt, the chances of their ever forming roots is very remote indeed. On very warm days sprinkling the cuttings occasionally will be a great help towards keeping them fresh and in a growing condition. In an atmospheric temperature of not lower than 56 degrees and not higher than 58 degrees at night and an under a bottom heat of ten degrees higher after the callous is formed, and the general temperature kept down in daytime as nearly to 65 degrees as possible, the cuttings should root in from twenty-one to twenty-five days sometimes longer according to the condition of the wood used from which the cutting is made, while some varieties root in much less time than others.

Grafting is frequently resorted to where the subject does not form roots readily, but that is not the case with the varieties of roses

under consideration, namely the white flowering Bride and the pink Bridesmaid, for no roses root with greater certainty than they. The great advantage the Manetti stock, before referred to, possesses for grafting purposes, is its strong tendency to produce numerous and vigorous roots, thus re-enforcing any variety, upon which a successful union—by grafting—with it has been made, against the many vicissitudes plant-life is heir to, whether said plants are growing outdoors or under glass, more especially perhaps when growing under the latter conditions.

A serious trouble with roses in some soils is the presence of the so-called eel worm, scientifically belonging to the nematode family. These little worms in some way chew and feed upon the roots, causing what is known as "club root," thus interfering with the regular functions of the roots, and in consequence the general health of the plant is impaired. When grafted upon the stock mentioned if the eel worm is present in the soil, the vigorous constitution of the stock in question has the power naturally to recuperate quickly, and therein is where its utility and strength lies.

There is another stock recommended under certain conditions for grafting purposes for roses, and that is the Rosa Multiflora, a wild rose of Japan. This stock, however, has been found too vigorous for the section of the tea-scented rose in general use for winter flowering, furnishing sap presumably more freely than the Tea roses mentioned above can elaborate to advantage. The American Beauty has so far shown no decided advantages when grafted on the Manetti stock, which, by the way, is itself increased by cuttings, whereas the Multiflora is very easily raised from seed, which is much the cheaper way to get up stock, and if the Beauty took kindly to the latter stock it might be advantageous to use it for that purpose, because Beauty does not root with nearly the same certainty as does a Tea rose. It may or it may not surprise some growers to know that Golden Gate and its white sport Ivory, with their natural vigorous constitution, are considered by other experts to be improved by grafting on the Manetti stock.

Before leaving the subject of grafting, it may be mentioned that dormant pieces, with two or three eyes and two and a half inches long or so, of the celebrated and popular Crimson Rambler rose, which is seen on every hand outdoors in full bloom in the month of June in and near to the larger cities, and grafted on any congenial stock—the Multiflora has been found admirable for this purpose—and given proper treatment under glass, may be had in full bloom in a four-inch pot the latter part of March or early in April, and such plants make excellent gifts for friends, or find ready sale if prepared with that object in view.

Carnations are easily raised from seed, but unfortunately out of one or two thousand young plants there may be no two alike and may be any other color than the variety which furnished the pollen or that which produced the seed, and two-thirds of the flowers are very likely to be single and of no practical value. But by seed is the way which such celebrities as "Mrs. Thomas W. Lawson," "The Roosevelt," "Prosperity," "Adonis," "Enchantress," and other meritorious varieties were brought forth; but to be absolutely sure that we will get the same color, form and size of any special variety, we must increase and multiply by cuttings. And what holds good in the case of roses in the propagating bed will serve as a guide to the management of Carnations, excepting that a cooler temperature is recommended for Carnations, from 52 to 55 degrees at night and not higher than 60 degrees in day time when possible and practical, with plenty of ventilation night and day, weather conditions permitting. Some varieties of Carnations are inclined to sport, so that a sharp lookout for a variation from the original is always in order.

Among the many favorite flowering plants for the greenhouse that may be raised annually from seed, are the Chinese Primrose (*Primula sinensis*), *Cineraria stellata* or the so-called hybrids from *C. cruenta* and *Cyclamen*, all of which are deserving of a place in any and all cool greenhouses where pot plants are grown. All the above delight in an abundance of air on all favorable occasions, and a night temperature of 45 degrees will suit them admirably. This brings us to the subject of—

ANNUALS FOR WINTER BLOOMING.

Nearly all the annual flowering plants may be had in bloom in the winter-time, provided the seed is sown at the proper time. The Mignonette is an annual and is one of the most popular flowers for winter blooming that we have, principally on account of its unique and delicious fragrance. The size of the flower has been wonderfully increased during the past decade. This has been brought about entirely by selection. One of the pioneers in the improvement of the size of the flowers of the Mignonette states, that he secured seed from every source likely to have something superior to what was generally grown, and when all the plants resulting therefrom came into bloom, only one plant was set aside as approaching the ideal, and from this one plant, seed was saved, and this rigid rejection was kept up for years until a vastly improved strain has been secured. And

what has been done for the Mignonette may be done for nearly if not quite all the flowering plants grown; especially does this apply to annuals. At present the Mignonette is the most popular annual grown for cut flowers, and the commercial value has been raised from a dollar per hundred twenty-five years ago, to fifty dollars per hundred, the latter price being realized at Chistmas time a few years ago. Though at the present time, I regret to say, so high price is not maintained even for the very select because the high grade has become more plentiful.

To find out just when to sow the seed of annuals to have them at a given time, at Christmas for instance, some experimenting will have to be resorted to and careful observations made and notes recorded. Mignonette for winter blooming is generally sown the latter part of July and the beginning of August, and as it is a difficult plant to transplant successfully, the seed is recommended to be sown where the plants are expected to grow and bloom; if in a bed under glass, after the soil is carefully prepared the bed is checked off a foot or so apart each way, a few seeds are dropped at the junction, exactly the same as is the general practice when planting corn. Other growers sow a few seeds in a three-inch pot. In all cases only one plant is left, and the thinning out is done as soon as possible after the plants become large enough so that the most promising one may be selected, thus giving same every opportunity to develop into a strong and vigorous specimen. And the plan adopted in the growing of Mignonette may with more or less modifications be carried out with other annuals. The methods of culture will have to conform according to the use to which the plant when fully grown is to be put. For instance, the Mignonette is not grown to any great extent as a pot plant, it not being sufficiently showy for that purpose, as it is grown principally for cut flowers. It is generally grown in a solid bed especially prepared inside the greenhouse, though we occasionally see some excellent specimens grown in pots.

Among other annuals that are successfully grown for winter flowering are the different varieties of Sweet Peas, and so far these are grown exclusively for cut flowers. The dwarf or Cupid varieties might be grown as pot plants, but the climbing varieties, to make presentable specimens, would have to be grown in large pots with the top of a birch tree or some other equally twigy bush to climb upon. All the varieties of Nasturtiums might be tried, both dwarf and climbing varieties. Some varieties would be found. after a test possibly, to answer the purpose for winter blooming better than others. In England such selections have already been made suitable to the existing conditions there. Whether the dwarf varieties would produce flowers with sufficiently long stems to be of any practical value in America for cut flowers can only be known by experimenting. Cer-

tain it is that as pot plants the dwarf varieties grown close to the glass in full sunlight, and in comparatively poor soil, and care taken not to give too much water, and in a temperature of from 56 to 60 degrees at night, very showy plants must result.

Among other hardy annuals besides those named may be mentioned, *Salpiglossis*, with its browns, yellows, and crimsons, beautifully veined in lighter or darker shades with occasional dashes of blue, giving color combinations difficult indeed to describe. There are dwarf and taller growing varieties but among the taller varieties there are none which might be given the term climbing.

Brachycome iberidifolia or Swan River Daisy, is dwarf and compact growing, with flowers both blue and white with darker center, and is very much like a refined form of the Cineraria. If grown dwarf and compact, these would make very beautiful plants for dinner table decoration.

Schizanthus in a variety of shades and colors as purples, lavenders, pinks and whites can be had in bloom in the winter without any difficulty whatever, and they are certainly very light, airy and graceful. There is a new variety known as *S. Wisetonensis*, which is likely to be heard of in the near future, as it has met with much favor in London recently.

In conclusion, let me admonish all who operate greenhouses, whether for pleasure or profit, to attend strictly to every little detail, for if anything requires strict attention in every detail, both large and small, it is greenhouse management. No matter whether for pleasure or profit, cleanliness must be the watchword, if there are a few meritorious specimen plants in a greenhouse or greenhouses, a lack of cleanliness detracts very materially from a place so operated, no matter how pretentious.

When a mixed collection of plants is grown they should be cleaned from decayed and decaying leaves and flowers and rearranged at least once a week. The variety in effect produced by judicious rearranging is another of the charms of a greenhouse, and it is needless to say that empty pots and dead and dying plants should be removed without delay. Plants respond very gratefully whenever intelligent attention is given to their needs.

PHOSPHATES.

PHOSPHATIC OR PHOSPHORIC ACID FERTILIZERS.

THE DIFFERENT SOURCES AND FORMS OF PHOSPHORIC ACID USED IN AGRICULTURE, AND THEIR METHODS OF PREPARATION AND APPLICATION.

BY H. J. PATTERSON,
Director and Chemsit of Maryland Agricultural Experiment Station.

INTRODUCTION.

Phosphates possess considerable interest to the agriculturist beyond their great importance in the every-day practical consideration of the means for maintaining and increasing the productive capacity of the land.

The foundation of the present system of agricultural chemistry was laid in connection with the study of the use of phosphates. The growth of agricultural chemistry, with the research based upon it, has brought about the development of the other sciences as related to agriculture and so produced all that may be encompassed by the term "Modern Scientific Agriculture." And phosphates may be said to be the initial of all that which may be hoped for as a result of the vast and world-wide efforts now being put forth in all classes of agricultural research.

HISTORICAL.

There is no definite record as to the time when the use of phosphates first came into existence, but as far as can be judged from the early records and writings upon agricultural topics, there seems to be but little doubt that the first commercial fertilizers ever used were chiefly phosphatic in their nature, and the good results which attended their application was mainly due to phosphoric acid.

From some notes of Varro it might appear that phosphates may have been used to some extent even B. C., but it is very sure, that even if such were the case, it was not until comparatively recent times that the value and need of phosphoric acid was actually recognized. Writers record that upon the first invasion of Britain by the Romans,

the natives were found using phosphatic marls to obtain better crops. But these practices were the result of accident or mere observation, and were not based upon any knowledge of the relations of soils, fertilizers and plants. The same is true of the practice of the Indians of putting fish in their hills of corn, as observed by the early settlers of America.

That there were no very definite ideas in the minds of the early users of phosphates or other mineral plant foods, at least ideas which correspond with the present existing theory of the relations of plants to mineral plant foods, is evidenced by the fact that the Prussian Academy of Sciences, in the year 1800, offered a prize for an investigation to decide whether the mineral matters found in plants are taken up from the soil or whether they are produced in the plants themselves by vital power. This question was treated by Schroader, whose decision was in favor of the latter opinion.

This opinion, though probably quite generally held, did not remain long in force, for Saussure, in 1804, declared that the mineral matter of humus contributed in a certain degree to fertility, since the same minerals are found in the ashes of plants. Sir Humphrey Davy was the first to consider the mineral constituents essential for the development of plants, as is evidenced by his statements in *Elements of Agricultural Chemistry*, London, 1814, to the effect that: "The chemistry of the simpler manures (the manures which act in very small quantities, such as bone dust, gypsum, alkalies and various saline substances), has hitherto been exceedingly obscure. It has been generally supposed that these materials act in the vegetable economy in the same manner as condiments or stimulants in the animal economy and that they render the common food more nutritive. It seems, however, a much more probable idea that they are actually a part of the true food of plants, and that they supply the kind of matter to the vegetable fiber which is analogous to the bony matter in animal stomachs." Springel, in his *Theory of Manuring*, published in 1839, was the second to express an opinion to this same effect. He said: "We can accept it as an indisputable fact that mineral matters found in plants are real nutrients for them, and that it is not their action upon humus which make them important, since gypsum, potassium, sulphate and calcium phosphate do not at all act upon the humus."

Closely following the statements of Springel, came (in 1840) the published results of the researches of Justus von Leibig. Leibig's results laid the foundation for our present agricultural chemistry, and entitled him to the designation of the "Father of Agricultural Chemistry."

While, as has been stated, mills for grinding bones existed early in the nineteenth century in France and England, and enterprising men went so far as to dig up battlefields and unearth thousands of tons of bones for agricultural purposes, and as it is even claimed that the credit for making the first super-phosphate is due to Sir James Murray, which was done in 1877, yet it was made without any real knowledge of the change which took place or application of the practical value accomplished.

As a result of his researches, Leibig pointed out that by treating bones and mineral phosphates with sulphuric acid, the insoluble phosphoric acid would be changed to a soluble form, and a considerable quantity of gypsum (sulphate of lime or land plaster), would be formed at the same time. The experiments of Leibig were substantiated by those conducted by the Duke of Richmond in comparing fresh and degelatinized bone from which he came to the conclusion that bones owed their fertilizing value not to gelatins or fatty matter, but to their large percentage of phosphoric acid. These experiments were still further confirmed by the results, shortly afterwards published by Boussingault. This set all uncertainty with regard to the value of phosphoric acid at rest and established its value and necessity on a permanent foundation, marked a distinct epoch in the uses of phosphates, which, from that time, has rapidly spread and been constantly increasing.

THE ROLE OF PHOSPHORIC ACID IN PLANTS.

The function which phosphoric acid performs in plants is quite varied, yet in all cases exceedingly essential. The present status of this subject has been fully set forth by Dr. Oscar Loew, in Bulletin No. 18, of the Division of Vegetable Pathology, U. S. Dept. of Agriculture, "On the Physiological Role of Mineral Nutrients." The principal points which it might be well to mention here are that the chlorophyll to which the green color of plants is due, can only be formed in the presence of phosphoric acid and, hence, all the essential functions which are closely related to the chlorophyll are dependent upon this element. Relatively large proportions are found in yeast cells, in seed just forming and numerous other microscopic organizations which are playing so important a part in the growth of plants. Proper embryo development of seeds seems to be dependent upon phosphates, and some observers have claimed that the total mass of protein in seeds is increased by an increased supply of phosphoric acid.

THE IMPORTANCE OF PHOSPHORIC ACID TO CROPS AND THE NEED FOR SUPPLYING IT IN FERTILIZERS.

It has already been stated that phosphoric acid was very necessary to the growth of crops and particularly essential to the maturity of seeds.

Though there is little loss of phosphoric acid from soils through any source except by crops, yet they draw on the soil to a considerable extent. The amount of phosphoric acid in various farm products and common products which farmers are familiar with is given in the following table, showing the fertilizing constituents:

TABLE 1.

SHOWING PHOSPHORIC ACID AND OTHER FERTILIZING CONSTITUENTS IN AGRICULTURAL PRODUCTS.

Compiled from Tables in Hand Book of Experiment Station Work, O. E. S. Bul. 15.

	Moisture—Per cent.	Ash—Per cent.	Nitrogen—Per cent.	Phosphoric acid—Per cent.	Potassium oxide—Per cent.
GREEN FODDERS.					
Corn fodder,	78.61	4.84	0.41	0.15	0.33
Sorghum fodder,	82.19	....	0.23	0.09	0.23
Rye fodder,	62.11	....	0.33	0.15	0.73
Oat fodder,	83.36	1.31	0.49	0.13	0.38
Common millet,	62.58	....	0.61	0.19	0.41
Japanese millet,	71.05	....	0.53	0.20	0.34
Hungarian grass (German millet),	74.31	....	0.39	0.16	0.55
Orchard grass (Dactylis glomerata),*	73.14	2.09	0.43	0.16	0.76
Timothy grass (Pleum pratense),*	66.90	2.15	0.48	0.26	0.76
Perennial rye grass (Lolium perenne),*	75.20	2.60	0.47	0.28	1.10
Italian rye grass ((Lolium italicum),*	74.85	2.84	0.54	0.29	1.14
Mixed pasture grasses,	63.12	3.27	0.91	0.23	0.75
Red clover (Trifolium pratense),	80.00	....	0.53	0.13	0.46
White clover (Trifolium repens),	81.00	....	0.56	0.20	0.24
Alsike clover, (Trifolium hybridum),	81.80	1.47	0.44	0.11	0.20
Scarlet clover (Trifolium incarnatum),	82.50	....	0.43	0.13	0.49
Alfalfa (Medicago sativa),	75.30	2.25	0.72	0.13	0.56
Cowpea,	78.81	1.47	0.27	0.10	0.31
Serradella (Orinthopus sativus),	82.59	1.82	0.41	0.14	0.42
Soja bean (Glycine soja),	73.20	....	0.29	0.15	0.53
Horse bean (Vicia faba),	74.71	....	0.68	0.33	1.37
White lupine (Lupinus albus),	85.35	....	0.44	0.35	1.73
Yellow lupine (Lupinus luteus),*	83.15	0.96	0.51	0.11	0.15
Flat pea (Lathyrus sylvestris),*	71.60	1.93	1.13	0.18	0.58
Common vetch (Vicia sativa),*	84.50	1.94	0.59	1.19	0.70
Prickley comfrey (Symphytum asperrinum),	84.36	2.45	0.42	0.11	0.75
Corn silage,	77.95	....	0.28	0.11	0.37
Corn and soja bean silage,	71.03	....	0.79	0.42	0.44
Apple pomace silage,*	75.00	1.05	0.32	0.15	0.40
HAY AND DRY COARSE FODDERS.					
Corn fodder (with ears),	7.85	4.91	1.76	0.54	0.89
Corn stover (without ears),	9.12	3.74	1.04	0.29	1.40
Teosinte (Euchlaena luxurians),	6.06	6.53	1.46	0.55	3.70
Common millet,	9.75	....	1.28	0.49	1.69
Japanese millet,	10.45	5.80	1.11	0.40	1.22
Hungarian grass,	7.69	6.18	1.20	0.35	1.30
Hay of mixed grasses,	11.99	6.34	1.41	0.27	1.55
Rowen of mixed grasses,	18.52	9.57	1.61	0.43	1.49
Redtop (Agrostis vulgaris),	7.71	4.59	1.15	0.36	1.02
Timothy,	7.52	4.93	1.26	0.53	0.90
Orchard grass,	8.84	6.42	1.31	0.41	1.88
Kentucky blue grass (Poa pratensis),	10.35	4.16	1.19	0.40	1.57
Meadow fescue (Festuca pratensis),	8.89	8.08	0.99	0.40	2.10
Tall meadow oat grass (Arrhenatherum avenaceum),	15.35	4.92	1.16	0.32	1.72
Meadow foxtail (Alopecurus pratensis),	15.35	5.24	1.54	0.44	1.99
Perennial rye grass,	9.13	6.79	1.23	0.56	1.55

TABLE 1—Continued.

	Moisture—Per cent.	Ash—Per cent.	Nitrogen—Per cent.	Phosphoric acid—Per cent.	Potassium oxide—Per cent.
Meadow foxtail (Alopecurus pratensis),	15.35	5.24	1.54	0.44	1.99
Perennial rye grass,	9.13	6.79	1.23	0.56	1.55
Italian rye grass,	8.71	....	1.19	0.56	1.27
Salt marsh hay,	5.36	....	1.18	0.25	0.72
Japanese buckwheat,	5.72	....	1.63	0.85	3.32
Red clover,	11.33	6.93	2.07	0.38	2.20
Mammoth red clover (Trifolium medium),	11.41	8.72	2.23	0.55	1.22
White clover,	....	....	2.75	0.52	1.81
Scarlet clover,*	18.30	7.70	2.05	0.40	1.31
Alsike clover,	9.94	11.11	2.34	0.67	2.23
Alfalfa,	6.55	7.07	2.19	0.51	1.68
Blue melilot (Melilotus caeruleus),	8.22	13.65	1.92	0.54	2.80
Bokhara clover (Melilotus alba),	7.43	7.70	1.98	0.56	1.83
Sainfoin (Onobrychis sativa),	12.17	7.55	2.63	0.76	2.02
Sulla (Hedysarum coronarium),	9.39	....	2.46	0.45	2.09
Lotus villosus,	11.52	8.23	2.10	0.59	1.81
Soja bean (whole plant),	6.30	6.47	2.32	0.67	1.08
Soja bean (straw),	13.00	....	1.75	0.40	1.32
Cowpea (whole plant),	10.95	8.40	1.95	0.52	1.47
Serradella,	7.39	10.60	2.70	0.78	0.65
Scotch tares,	15.80	....	2.96	0.82	3.00
Oxeye daisy (Chrysanthemum leucanthemum),	9.65	6.37	0.28	0.44	1.25
Dry carrot tops,	9.76	12.52	3.13	0.61	4.88
Barley straw,	11.44	5.30	1.31	0.30	2.09
Barley chaff,	13.08	....	1.01	0.27	0.99
Wheat straw,	12.56	3.81	0.59	0.12	0.51
Wheat chaff,	8.05	7.18	0.79	0.70	0.42
Rye straw,	71.61	3.25	0.46	0.28	0.79
Oat straw,	9.09	4.76	0.62	0.20	1.24
Buckwheat hulls,	11.90	....	0.49	0.07	0.52
ROOTS, BULBS, TUBERS, ETC.					
Potatoes,	79.75	0.99	0.21	0.07	0.29
Red beets,	87.73	1.13	0.24	0.09	0.44
Yellow fodder beets,	90.60	0.95	0.19	0.09	0.46
Sugar beets,	86.95	1.04	0.22	0.10	0.48
Mangel-wurzels,	87.29	1.22	0.19	0.09	0.38
Turnips,	89.49	1.01	0.18	0.10	0.39
Rutabagas,	89.13	1.06	0.19	0.12	0.49
Carrots,	89.79	9.22	0.15	0.09	0.51
GRAINS AND OTHER SEEDS.					
Corn kernels,	10.88	1.53	1.82	0.70	0.40
Sorghum seed,	14.00	....	1.48	0.81	0.42
Barley,*	14.30	2.48	1.51	0.79	0.48
Oats,	18.17	2.98	2.06	0.82	0.62
Wheat (spring),	14.35	1.57	2.36	0.70	0.39
Wheat (winter),	14.75	....	2.36	0.89	0.61
Rye,	14.90	....	1.76	0.82	0.54
Common millet,	12.68	....	2.04	0.85	0.36
Japanese millet,	13.68	....	1.73	0.69	0.38
Rice	12.60	0.82	1.08	0.18	0.09
Buckwheat,	14.10	....	1.44	0.44	0.21
Soja beans,	18.33	4.99	5.30	1.87	1.99
MILL PRODUCTS.					
Corn meal,	12.95	1.41	1.58	0.63	0.40
Corn-and-cob meal,	8.96	....	1.41	0.57	0.47
Ground oats,	11.17	3.37	1.86	0.77	0.59
Ground barley,	13.43	2.06	1.55	0.66	0.34
Rye flour,	14.20	....	1.68	0.85	0.65
Wheat flour,	9.83	1.22	2.21	0.57	0.54
Pea meal,	8.85	2.68	3.08	0.82	0.99

TABLE 1—Continued.

	Moisture—Per cent.	Ash—Per cent.	Nitrogen—Per cent.	Phosphoric acid—Per cent.	Potassium oxide—Per cent.
BY-PRODUCTS AND WASTE MATERIALS.					
Corn cobs,	12.09	0.82	0.50	0.06	0.60
Hominy feed,	8.93	2.21	1.63	0.98	0.49
Gluten meal,	8.59	0.73	5.03	0.33	0.05
Starch feed (glucose refuse),	8.10	....	2.62	0.29	0.15
Malt sprouts,	10.38	12.48	3.55	1.43	1.63
Brewers' grains (dry),	6.98	6.15	3.05	1.26	1.55
Brewers' grains (wet),	75.01	....	0.89	0.31	0.05
Rye bran,	12.50	4.60	2.32	2.28	1.40
Rye middlings,*	12.54	3.52	1.84	1.26	0.81
Wheat bran,	11.74	6.25	2.67	2.39	1.61
Wheat middlings,	9.18	2.30	2.63	0.95	0.63
Rice bran,	10.20	12.94	0.71	0.29	0.24
Rice polish,	10.30	9.00	1.97	2.67	0.71
Buckwheat middlings,*	14.70	1.40	1.38	0.68	0.34
Cotton-seed meal,	9.90	6.82	6.64	2.68	1.79
Cotton-seed hulls,	10.63	2.61	0.75	0.18	1.08
Linseed meal (old process),	8.88	6.08	5.43	1.66	1.37
Linseed meal (new process),	7.77	5.37	5.78	1.83	1.39
Apple pomace,	80.50	0.27	0.23	0.02	0.13
VEGETABLES					
Artichokes,	81.50	0.99	0.36	0.17	0.48
Asparagus stems,	93.96	0.67	0.29	0.08	0.29
Beans, adzuki,	15.86	3.53	3.29	0.95	1.51
Beans, Lima,	68.46	1.69	....	....	....
Beans, string,	87.2[illegible]	0.76	....	....	....
Beets, red,	88.47	1.04	0.24	†0.09	†0.41
Cabbages,	90.52	1.40	0.38	†0.11	†0.43
Carrots,	88.59	1.02	0.16	0.09	0.51
Cauliflower,	90.82	0.81	0.14	0.16	0.36
Chorogi, tubers,	78.90	1.09	1.92	0.19	0.64
Chorogi, whole plant,	78.33	1.02	....	....	....
Cucumbers,	95.99	0.46	0.16	0.12	0.24
Eggplant,	92.[illegible]3	0.[illegible]	....	....	....
Horse-radish root,	76.68	1.87	0.36	0.07	1.16
Kohl-rabi,	91.08	1.27	0.48	0.27	0.43
Lettuce leaves,	86.28	1.71	....	....	....
Lettuce stems,	88.46	1.18	....	....	....
Lettuce, whole plant,	93.68	1.61	0.23	*0.07	*0.37
Muskmelons, interior juice,	91.62	1.01	....	....	....
Muskmelons, pulp,	76.41	1.4[illegible]	....	....	....
Muskmelons, pulp juice,	[illegible]	0.76	....	....	....
Muskmelons, rind,	91.15	0.68	....	....	....
Mustard, white,	84.19	2.25	....	....	....
Okra,	87.41	0.74	....	....	....
Onions,	87.55	0.57	0.14	0.04	0.10
Parsnips,	80.34	1.03	0.22	0.19	0.62
Peas, Canada field,	12.48	2.36	....	....	....
Peas, garden,	12.62	3.11	3.58	0.84	1.01
Peas, green,	79.93	0.78	....	....	....
Peas, small (Lathyrus savitus), whole plant,	5.80	5.94	2.50	0.59	1.99
Pumpkins, flesh,	93.[illegible]9	0.67	....	....	....
Pumpkins, rind,	86.23	1.[illegible]6	....	....	....
Pumpkins, seeds and stringy matter,	76.86	1.51	....	....	....
Pumpkins, whole fruit,	92.27	0.63	*0.11	*0.16	*0.09
Rhubarb, roots,	74.35	2.28	0.55	0.06	0.53
Rhubarb stems,	92.67	0.94	....	....	....
Rhubarb, stems and leaves,	91.67	1.72	0.13	0.02	0.36
Rutabagas,	88.61	1.15	0.19	0.12	0.49
Spinach,	92.42	1.94	0.49	0.16	0.27
Squashes, flesh,	88.09	1.72	....	....	....

TABLE 1—Continued.

	Moisture—Per cent.	Ash—Per cent.	Nitrogen—Per cent.	Phosphoric acid—Per cent.	Potassium oxide—Per cent.
Squashes, rind,	82.00	1.21	....	....	....
Squashes, seeds and stringy matter,	74.03	1.39	....	....	....
Squashes, whole fruit,	94.88	0.41	....	....	....
Sweet corn, cobs,	80.10	0.59	0.21	0.05	0.22
Sweet corn, husks,	86.19	0.56	0.18	0.07	0.22
Sweet corn, kernels,	82.14	0.56	0.46	0.07	0.24
Sweet corn, stalks,	80.86	1.25	0.28	0.14	0.41
Sweet potatoes, tubers,	71.26	1.00	*0.24	*0.08	*0.37
Sweet potatoes, vines,	41.55	5.74	....	....	....
Tobacco,†	....	18.27	....	0.55	3.81
Tomatoes, fruit,	93.64	0.47	0.16	0.05	0.27
Tomatoes, roots,	73.31	11.72	0.24	0.06	0.29
Tomatoes, vines,	83.61	3.00	0.32	0.07	0.50
Turnips,	90.46	0.80	0.18	0.10	0.39
Watermelons, juice,	93.05	0.20	....	....	....
Watermelons, pulp,	91.87	0.33	....	....	....
Watermelons, rind,	89.97	1.24	....	....	....
Watermelons, seeds,	48.37	1.34	....	....	....
Apple leaves, collected in May,	72.36	2.33	0.74	0.25	0.25
Apple leaves, collected in September,	60.71	3.46	0.89	0.19	0.39
Apple, fruit,	85.30	0.39	0.13	0.01	0.19
Apple trees (young), branches,	83.60	0.65	....	0.04	0.04
Apple trees (young), roots,	64.70	1.59	....	0.11	0.09
Apple trees (young), trunks,	51.70	1.17	....	0.06	0.06
Apple trees (young), whole plant,	60.83	....	0.35	0.05	0.17
Apricots, dried,	32.44	1.38	....	....	....
Apricots, fresh,	85.16	0.49	0.19	0.06	0.29
Bananas, fresh,	66.25	1.15	....	....	....
Blackberries,	88.91	0.58	0.15	0.09	0.20
Blueberries,	82.69	0.16	0.14	0.05	0.05
Cherries, fruit,	86.10	0.58	0.18	*0.06	*0.20
Cherry trees (young), branches,	79.50	0.78	....	0.05	0.06
Cherry trees (young), roots,	67.20	1.22	....	0.08	0.07
Cherry trees (young), trunks,	53.20	0.81	....	0.04	0.06
China berries,	16.52	4.13	1.19	0.43	2.33
Cranberries, fruit,	89.59	0.18	....	0.03	0.09
Cranberries, vines,	....	2.45	....	0.27	0.32
Currants,	86.02	0.53	....	0.11	0.27
Grapes, fruit, fresh,	83.00	0.50	0.16	0.09	0.27
Grapes, fruit, dried and ground,†	34.83	1.16	....	....	....
Grapes, wood of vine,	....	2.97	....	0.42	0.67
Lemons,	83.83	0.56	0.15	0.06	0.27
Nectarines,	79.00	0.50	0.12	....	....
Olives, fruit,§	58.00	1.42	0.18	0.12	0.86
Olives, leaves,§	42.40	2.51	0.91	0.26	0.76
Olives, wood of larger branches,§	14.50	0.94	0.88	0.11	0.18
Olives, wood of small branches,§	18.75	0.96	0.89	0.12	0.20
Oranges, California,	85.21	0.43	0.19	0.05	0.21
Oranges, Florida,	87.71	....	0.12	0.08	0.48
Peaches, fruit,	87.85	0.32	....	0.05	0.24
Peaches, wood of branches,	58.26	1.93	0.90	0.22	0.50
Pears, fruit,	83.92	0.54	0.09	0.03	0.08
Pear trees (young), branches,	84.00	0.76	....	0.04	0.08
Pear trees (young), roots,	66.70	1.40	....	0.07	0.11
Pear trees (young), trunks,	49.30	1.71	....	0.07	0.13
Pineapples,	89.28	0.35	....	....	....
Plums,	47.43	0.54	0.18	0.02	0.24
Prunes,	77.38	0.49	0.16	0.07	0.31
Raspberries,	81.82	0.55	0.15	0.48	0.35
Strawberries, fruit,	90.84	0.60	0.15	0.11	0.30
Strawberries, vines,	....	3.34	....	0.48	0.35

TABLE 1—Continued.

	Moisture—Per cent.	Ash—Per cent.	Nitrogen—Per cent.	Phosphoric acid—Per cent.	Potassium oxide—Per cent.
Whortleberries,	82.42	0.41	....	....	....
Chestnuts, cultivated,	40.00	1.78	....	....	....
Chestnuts, native,	40.00	1.62	1.18	0.39	0.63
Chestnuts, Spanish,	10.00	2.66	....	....	....
Peanuts, hulls,	10.00	2.99	1.04	0.14	0.81
Peanuts, kernels,	10.00	2.21	4.01	0.82	0.88
Peanuts, vines after blooming,	10.00	12.36	....	0.20	0.90
Peanuts, vines before blooming,	30.00	7.45	....	0.32	1.16
WOOD.					
Ash wood,	10.00	0.32	....	0.012	0.149
Chestnut, bark,	10.00	3.51	....	0.114	0.278
Chestnut, wood,	10.00	0.16	....	0.011	0.029
Dogwood, bark,	10.00	9.87	....	0.140	0.341
Dogwood, wood,	10.00	0.68	....	0.057	0.190
Hickory, bark,	10.00	3.97	....	0.061	0.141
Hickory, wood,	10.00	0.48	....	0.058	0.138
Magnolia, bark,	10.00	2.98	....	0.095	0.192
Magnolia, wood,	10.00	0.36	....	0.032	0.071
Maple, bark,	10.00	9.49	....	0.421	1.197
Oak leaves, mixed,	....	4.70	....	....	....
Oak post, bark,	10.00	12.10	....	0.116	0.249
Oak post, wood,	10.00	0.77	....	0.070	0.169
Oak, red, bark,	10.00	6.29	....	0.103	0.179
Oak, red, wood,	10.00	0.57	....	0.060	0.140
Oak, white, bark,	10.00	5.95	....	0.074	0.125
Oak, white, wood,	10.00	0.26	....	0.025	0.106
Pine, burr,	....	1.09	....	....	....
Pine, Georgia, bark,	10.00	0.37	....	0.013	0.024
Pine, Georgia, wood,	10.00	0.33	....	0.012	0.050
Pine, old field, bark,	10.00	1.94	....	0.095	0.077
Pine, old field, wood,	10.00	0.18	....	0.007	0.008
Pine, straw, mixed,	....	1.65	....	....	....
Pine, yellow, wood,	10.00	0.23	....	0.010	0.045
Pine, black, wood,	10.00	0.21	....	0.009	0.030
Sycamore, wood,	10.00	0.99	....	0.121	0.230
ANIMAL PRODUCTS.					
Butter,	7.91	0.15	0.12	0.040	0.040
Buttermilk (85),	90.12	0.72	0.64	0.220	0.210
Cheese,	33.25	2.10	3.93	0.600	0.120
Cream,	74.05	0.50	0.40	0.150	0.130
Eggs,	67.20	6.18	2.18	0.370	0.150
Eggs without shell,	73.70	0.92	2.00	0.350	0.160
Fat renderings, cakes (5),	9.52	6.38	9.38	2.620	0.199
Calf,	66.20	3.80	2.50	1.380	0.240
Ox,	59.7	4.66	2.66	1.860	0.170
Sheep,	59.1	3.17	2.24	1.230	0.150
Swine,	52.00	2.16	2.00	0.880	0.180
Cow's milk,	87.00	0.75	0.53	0.190	0.180
Skim milk,	90.25	0.80	0.56	0.200	0.190
Skim milk, centrifugal separation (7),	9.60	0.74	0.49	0.210	0.200
Whey,	92.97	0.60	0.150	0.140	0.180
Wool, washed,	12.80	0.98	9.44	0.180	0.190
Wool, unwashed,	15.00	7.08	5.40	0.070	5.620

*Dietrich and Konig: Zusamensetzung und Vardaulichkeit der Futtermittel.
*Dietrich and Konig.
†Wolff.
§Average of 50 analyses made by H. J. Patterson.
†"Grape food."
§L. Paparelli: Etude chiue sur l'oliver, Montpelier, 1881.

From the figures in Table 1 may be determined the amount of phosphoric acid disposed of in the products sold off the farm.

The quantities of phosphoric acid contained in the usual unit of measure of the more common products, together with the valuation of the same upon the basis of the commercial value of fertilizers is given in the following table:

TABLE 2.

Quantity and Value of the Phosphoric Acid Contained in the more Common Farm Products.

(Calculated on the Basis of the Ordinary Unit of Measure.)

Number.	Kind and Quantity of Product.	Quantity of phosphoric acid—Lbs.	Value—Cts.*	Amount which contains $1.00 worth of phosphoric acid.
	GRAINS AND SEEDS.			
1	1 bushel barley, 48 lbs.,	0.38	1.9	52.6 bushels.
2	1 bushel buckwheat, 48 lbs.,	0.21	1.0	100.0 bushels.
3	1 bushel clover seed, 60 lbs.,	0.87	4.3	23.3 bushels.
4	1 bushel corn, 56 lbs.,	0.39	1.9	52.6 bushels.
5	1 bushel oats, 32 lbs.,	0.26	1.3	77.0 bushels.
6	1 bushel rye, 56 lbs.,	0.46	2.3	43.5 bushels.
7	1 bushel timothy seed, 45 lbs.,	0.53	2.6	38.5 bushels.
8	1 bushel wheat, 60 lbs.,	0.53	2.6	38.5 bushels.
	HAY AND STRAW.			
9	1 ton clover hay,	3.8	19.0	5.3 tons.
10	1 ton timothy hay,	5.3	26.5	3.8 tons.
11	1 ton rye straw,	2.8	14.0	7.1 tons.
12	1 ton wheat straw,	1.2	6.0	16.7 tons.
	VEGETABLES AND FRUITS (60 lbs. each).			
13	1 bushel apples,	0.006	....	3,333.0 bushels.
14	1 bushel cabbage,	0.066	....	303.0 bushels.
15	1 bushel grapes,	0.050	....	400.0 bushels.
16	1 bushel peaches,	0.030	....	667.0 bushels.
17	1 bushel pears,	0.015	....	1,333.0 bushels.
18	1 bushel potatoes,	0.042	*	476 bushels.
19	1 bushel strawberries,	0.066	....	303 bushels.
20	1 bushel tomatoes,	0.030	....	667 bushels.
21	1 bushel turnips,	0.060	....	333 bushels.
	ANIMAL PRODUCTS.			
22	1 tub butter, 100 lbs.,	0.04	0.002	500 tubs.
23	1 can cream,† 10 gals., 80 lbs.,	0.12	0.006	167 cans.
24	1 can milk, 10 gal., 88 lbs.,	0.17	0.008	125 cans.
25	1 crate of eggs, 12 doz., 18 lbs.,	0.07	0.004	286 crates.
26	1 bale wool, 100 lbs.,	0.07	0.004	286 bales.
27	1,000 lbs. steer,	18.6	0.930	....
28	1,000 lbs. of sheep,	12.3	0.615	....
29	1,000 lbs. of hogs,	8.8	0.440	....

*At the rate of 5 cents per pound.

†Cream testing 20 to 25 per cent. fat.

In order to present an idea of the amount of exhaustion of phosphoric acid by crop in a little different way from the above, calculations have been made of the quantity removed from one acre by a fair yield of some of the commoner products. These figures are presented in Table 3.

TABLE 3.

Approximate Quantity of Phosphoric Acid in the Product of One Acre of Sundry Farm Crops.

Estimated Crop.	Phosphoric acid—Lbs.	Value of phosphoric acid—Cts.	Quantity of dissolved South Carolina rock* to supply the phosphoric acid—Lbs.
Corn, 50 bushels,	16.0	80	115
Oats, 40 bushels,	10.4	52	74
Wheat, 25 bushels,	12.0	60	86
Potatoes, 150 bushels,	14.4	72	103
Tomatoes, 10 tons,	4.2	21	30
Clover hay, 2 tons,	22.4	112	160
Timothy hay, 2 tons,	27.6	138	197
Wheat straw, 1¼ tons,	5.5	28	40
Green fodder corn, 15 tons,	30.0	150	214

*Calculated on the basis of 14 per cent. available phosphoric acid.

The figures given in Table 3 are not intended to show the amount of phosphoric acid needed for the growth of the whole plant or crop, but simply what would be removed in the parts which are generally sold.

The quantities of phosphoric acid which are removed by one bushel of product or even by a crop from one acre as exhibited by the figures in the preceding table, in most cases seem to be very small and, indeed, almost insignificant, yet, when the fact is considered that most of the lands have been under cultivation for a considerable length of time, it will be seen that even these small amounts represent considerable when multiplied by 10, 20, 50 and even 100 or more crops. The figures which have been given in Tables 1, 2 and 3 will serve the purpose for each person to gain some idea of what is taking place in individual cases, but give little conception of the vastness of what is taking place in the State as a whole.

The annual drain of phosphoric acid from the farms of Pennsylvania, by the principal crops, is shown by the figures in Table 4. Though large as these figures seem, yet they represent but a part of what is taking place. The amount removed by over one million

dollars' worth of truck crops and small fruits annually sold from Pennsylvania farms is not accounted for in the table. Again, the live stock, poultry and eggs annually sold carry considerable phosphoric acid with them.

The total amount removed by the crops, as exhibited in Table 4, of 102,538,740 pounds would require, if it were to be replaced, over 366 thousand tons of standard (14 per cent.) dissolved phosphate rock. This would mean an expenditure of over three and one-half millions of dollars annually for this one plant food alone.

TABLE 4.

The Approximate Quantity of Phosphoric Acid Annually Removed from Pennsylvania Farms by the Principal Crops.

(Compiled from Yields of the Twelfth Census, 1900.)

Crops.	Bushels.	Pounds.	Phosphoric acid, per cent.	Pounds of phosphoric acid
Barley,	197,178	9,464,521	0.79	74,769
Barley straw,	....	15,389,690	0.30	46,169
Buckwheat,	3,922,980	188,295,240	0.44	828,499
Buckwheat straw,	....	320,101,908	0.61	1,952,621
Corn grain,	51,869,780	2,904,707,680	0.70	20,332,953
Corn fodder,	....	5,809,415,360	0.29	16,847,304
Oats,	37,242,810	968,313,060	0.82	7,940,367
Oat straw,	....	1,646,132,202	0.20	3,292,264
Rye,	3,944,750	220,906,000	0.82	1,811,429
Rye straw,	....	375,540,200	0.20	751,080
Wheat,	20,632,680	1,237,960,800	0.89	11,004,851
Wheat straw,	....	2,104,533,360	0.12	2,525,440
Potatoes,	21,769,472	1,219,090,432	0.07	853,363
Sweet potatoes,	234,724	13,144,544	0.08	10,515
Onions,	347,806	19,477,136	0.04	7,790
Tobacco (lbs.),	41,502,620	41,502,620	0.55	228,264
Beans,	23,957	1,341,592	0.95	12,745
Peas,	6,363	356,328	0.84	2,993
Hay and forage (tons),	3,766,834	7,533,668,000	0.45	33,901,506
Total,				102,421,922

Before proceeding further, it will probably be well to devote a little space to the general consideration of the subject of phosphoric manures, the forms in which phosphoric acids exist, and various sources and methods of manufacture of the same.

Phosphoric Acid and Phosphates:—Phosphorus compounds are absolutely necessary for the maturity of plants and the formation of seeds for their reproduction. It has been well established

that the salts of phosphoric acid, or phosphates, as they are called, are the only sources from which phosphorus of plants can be derived. Phosphoric acid is a combination of the element Phosphorus (P) with Oxygen gas (O). In phosphates, the phosphorus and oxygen unite in the proportion of two parts of the former to five of the latter, forming what is commonly designated as *phosphoric acid*, and this union is expressed by the sign or symbol $P_2 O_5$. Phosphorus, when uncombined with other elements, is a yellowish, waxy looking, solid substance. It is soft and can be cut as easily as ordinary bees-wax. It is very poisonous. It ignites easily, and, therefore, has to be kept under water. When phosphorus burns, it simply unites with the oxygen of the air, forming phosphoric acid ($P_2 O_5$).

Phosphoric acid usually occurs in the soil in combination with lime, magnesia, alumina and iron. These phosphates are all practically insoluble in water; that is, they are dissolved by pure water so slowly and to so slight an extent that they sustain no appreciable loss in the soil by drainage water. Hence, the quantity in the soil is diminished almost wholly through the agency of crops. The amount of phosphoric acid, even in a fertile soil, is comparatively small. A ton of good soil will contain about three pounds; many will contain less, and some considerably more. On this basis an acre of average soil would contain to the depth of 9 inches, about 4,500 pounds of phosphoric acid.

The character of the soil affects very considerably, the available condition of the plant food. One of the problems that confronts the farmer is to use such methods in soil management as will convert the plant foods which the soil contains into forms available for crops.

FORMS OF PHOSPHORIC ACID.

As has already been stated, phosphoric acid exists in soils in combination with lime, magnesia, alumina and iron, and it is in these same combinations in which it is found in the various sources, from which phosphates are manufactured. For the manufacture of fertilizer and in agriculture, the phosphate of lime is most highly prized and preferred.

IRON AND ALUMNIA PHOSPHATES.

This represents a large class of natural phosphates. They are insoluble in water, the same as the natural lime phosphate. They contain almost the same percentage of phosphoric acid as lime phosphates. They are not well adapted for the manufacture of soluble phosphates as the treatment with acid produces a sticky mass which is hard to dry and keep in a good condition.

FORMS OF PHOSPHATE OF LIME.

In manufacturing fertilizer from phosphate of lime the aim has been to change it from the insoluble condition to a soluble condition which would be more available to plants. In the natural and insoluble state, the phosphate exists in what is chemically known as *tri-calcium phosphate* (three-lime phosphate), and in the course of manufacture this is changed chemically so that, at the end of the operation there exists four kinds or combinations of calcium (lime) and phosphoric acid, which are as follows:

(1.) Soluble phosphate of lime, or mono-calcium phosphate.

(2.) Reverted phosphate of lime, or di-calcium phosphate.

(3.) Insoluble phosphate of lime, or tri-calcium phosphate.

(4.) Tetra-calcium phosphate, or four-lime phosphate.

(1) SOLUBLE PHOSPHATE OF LIME.

This is popularly known under several other names as "Super-phosphate," "Super-phosphate of lime," "Acid phosphate," "Acid phosphate of lime," "Water-soluble phosphate," "Acid calcium phosphate," "Mono-calcium phosphate," and "One-lime phosphate." Phosphoric acid does not occur naturally in the soluble state.

Soluble phosphoric acid is made by treating bones or mineral phosphates with sulphuric acid (oil of vitriol.) The chemical change which occurs is practically as follows: Sulphuric acid and water being applied to the materials containing insoluble phosphates (tri-calcium phosphate), the sulphuric acid combines chemically with two parts of lime and forms sulphate of lime or gypsum (land plaster), while the water unites with the phosphoric acid and one part of lime, forming mono-calcium or soluble phosphate of lime. The substances being mixed, it is a natural chemical action or reaction that takes place with the result stated. The total conversion of the insoluble to the soluble form, cannot be accomplished without using such an excess of sulphuric acid as would be injurious to seeds and roots of plants which would come in contact with the fertilizer, and also would make the fertilizer of such a mechanical condition as to be difficult to handle and apply. In practice, less acid is added than is necessary to wholly convert all the phosphoric acid to the soluble form, consequently more or less of all the forms of phosphoric acid are found to be present after the fertilizing materials have been treated or dissolved. Leibig, in 1840, was the first person to suggest the treatment of bones and mineral phosphates with sulphuric acid, for the purpose of rendering the phosphoric acid more available for plants. This may be said to be the beginning of the use of genuine artificial fertilizers. In the course of dissolving phosphates some of the phosphoric acid is set entirely free and

will be found as free phosphoric acid in freshly made goods, but this will remain so for only a comparatively short time. It will, in time, act on the insoluble phosphates contained in the fertilizer.

The water-soluble phosphoric acid is readily distributed in the soil, and is in a form that can be immediately absorbed by the roots and used by the plants as food, but, unfortunately, the water-soluble phosphoric acid will not remain long in the soil in this condition, for, coming in contact with the lime, magnesia, etc., in the soil, it reverts to a condition insoluble in water. In reverting, this water-soluble phosphoric acid is precipitated in such a way as to form a fine powder or coat over the particles of soil, and is thus in a finely divided state and presents a considerable surface which makes it easily dissolved by the acid soil waters, and the acid exudations of rootlets and thus still possesses a greater availability than any other form of phosphoric acid.

(2) REVERTED PHOSPHATE OF LIME.

Reverted phosphate of lime, also spoken of as "Reverted phosphoric acid," "Reverted calcium phosphate," "Precipitated phosphate of lime," "Citrate soluble phosphate," "Neutral phosphate of lime," and "Di-calcium phosphate," is quite insoluble in pure water, but is easily dissolved in water containing carbonic acid or salts of ammonia and in weak acids. The term reverted was originally intended to imply that this phosphoric acid had once been soluble, but for some cause had "gone back" to a form insoluble in water. This probably does take place to a limited extent, but as a matter of fact, in the course of manufacture, there is not sufficient acid used to make all the phosphoric acid soluble, and some of the tri-calcium phosphate loses only one part of lime, and thus leaves di-calcium phosphate remaining. As has been stated, some phosphoric acid is set entirely free, which will unite with insoluble phosphoric acid, and bring some of it to the so-called reverted form. This form of phosphoric acid is readily assimilated by plants, because the soil and solutions from the plant roots usually contain acids strong enough to dissolve it. Reverted phosphoric acid is, therefore, considered nearly as valuable as a plant food as the water-soluble form. Reverted phosphoric acid is often met with in small quantities in nature in connection with some insoluble phosphates, guanos, limes and other organic matter.

AVAILABLE PHOSPHORIC ACID.

In the commercial world and in stating the results of an analysis, the percentage of soluble phosphoric acid and the reverted or citrate soluble phosphoric acid are added together and the sum called *available phosphoric acid.*

(3) INSOLUBLE PHOSPHORIC ACID.

This is known under several names, as "Insoluble calcium phosphate," "Tri-calcium phosphate," "Bone phosphate of lime" and "Normal calcium phosphate." This form is called insoluble, because it does not dissolve in water or weak acids, as does the soluble or reverted phosphoric acid, but requires some strong acid to cause its decomposition or solution.

Insoluble phosphoric acid is found in nature in large quantities, some of the chief sources of which will be noticed later.

Insoluble phosphates are found everywhere in the soil and most of them are of but little value to the farmer, because they are not easily dissolved and can, therefore, be utilized but slowly by plants.

(4) TETRA-CALCIUM PHOSPHATES.

Tetra-calcium phosphate, or four-lime phosphate, is a form of phosphoric acid of recent discovery, and has been found to exist in slag phosphates. It contains more lime in proportion to phosphoric acid than any other form of phosphate. While it is insoluble in water, it has been found to be more available to plants than insoluble phosphate of lime (tri-calcium phosphate).

The following table gives the chemical composition and differences of the four phosphates of lime:

TABLE 5.

Chemical Composition of the Four Phosphates of Lime.

	Calcium—Per cent.	Phosphorus—Per cent.	Oxygen—Per cent.	Hydrogen—Per cent.
1. Soluble phosphate of lime,	17.1	26.5	54.7	1.7
2. Reverted phosphate of lime,	29.4	22.8	47.0	0.8
3. Insoluble phosphate of lime,	38.7	20.0	41.3	....
4. Tetra-calcium phosphate,	43.7	17.0	39.3	....

Or, taking it another way:

	Phosphoric acid P_2O_5 —Per cent.	Lime CaO—Per cent.	Water H_2O—Per cent.
1. Soluble phosphate of lime,	60.68	23.93	15.39
2. Reverted phosphate of lime,	52.20	41.18	6.62
3. Insoluble phosphate of lime,	45.81	54.19	....
4. Tetra-calcium phosphate,	38.79	61.21	....

TOTAL PHOSPHORIC ACID.

The total phosphoric acid is the sum of all the forms of phosphoric acid which a given fertilizer contains. In ordering dissolved rock, for instance, the total is equal to the soluble, reverted and insoluble phosphoric acid contained therein.

METHOD OF MANUFACTURING SOLUBLE PHOSPHATES.

The process of manufacturing soluble phosphates from bones or mineral phosphates is not very complicated, yet requires some chemical knowledge and experience, and facilities for carrying on the operation. The raw phosphates, whether of animal or mineral origin, are quite variable in their physical condition and chemical composition, yet the phosphoric acid will be found to be combined with lime, in the proportion of one part of the former to three of the latter, forming the tri-calcium phosphate.

The chief result which the manufacturer desires to arrive at is to make the tri-calcium phosphate soluble in water or in neutral ammonium citrate. To do this the chemist has worked upon the following basis: Sulphuric acid is known to be more energetic in its action at ordinary temperature than any other acid used in industry. It, therefore, has the power of displacing all other acids from their salts and of taking their bases to itself to form sulphates, which, for the most part, are quite staple and easily handled substances. The acids which are chiefly present in natural phosphates are phosphoric, carbonic, fluoric and silicic. These, when brought in contact with dilute sulphuric acid, are all displaced, and the bases become sulphates. Chemists have determined how much sulphuric acid is required to displace each of the various acids present, and to form sulphates with the bases with which they are combined, so that, after the composition of a natural mineral phosphate has been determined, the amount of sulphuric acid of a given strength which

it is necessary to use in order to bring the desired change of a tri calcium phosphate to the soluble and reverted forms, can be easily calculated. These amounts have been worked out for practice as expressed in the following table:

TABLE 6.*

One Part by Weight of Each Substance Below Requires, Sulphuric Acid by Same Unite of Weight.

	At 48° B.	At 50° B.	At 52° B.	At 54° B.	At 55° B.
Tri-calcium phosphate,	1.590	1.517	1.416	1.382	1.352
Iron phosphate,	1.630	1.558	1.485	1.420	1.390
Aluminum phosphate,	2.025	1.930	1.839	1.756	1.721
Calcium carbonate,	1.640	1.565	1.495	1.428	1.411
Calcium fluoride,	2.060	2.010	1.916	1.830	1.794
Magnesium carbonate,	1.940	1.860	1.775	1.690	1.660

*H. W. Wiley's "Principles and Practice of Agricultural Analysis," Vol. II, pp. 155.

Example.—Suppose, for example, a phosphate of the following composition, is to be treated with sulphuric acid, viz:

	Per cent.
Moisture and organic,	4.00
Calcium phosphate,	55.00
Calcium carbonate,	3.0[illegible]
Iron and aluminum phosphate, nearly all A.,	6.50
Magnesium carbonate,	0.75
Calcium fluoride,	2.25
Insoluble,	28.00

Using sulphuric acid of 50° B., the following quantities will be required for 100 kilograms:

	Kilos* of acid required.
Calcium phosphate, fifty-five kilos,	83.4
Calcium carbonate, three and a half kilos,	5.48
Calcium fluoride ,two and a quarter kilos,	4.52
Aluminum and iron phosphate, six and a half kilos,	12.55
Magnesium carbonate, three-quarters of a kilo,	1.40
Total,	107.39

*One kilo—about 2.2 lbs.

The material, before treatment, is always finely ground so as to facilitate the chemical action. After the treatment has been completed the mass is dried and ground for use.

The materials which are chiefly used as sources of phosphoric acid in fertilizers are given in the following table, together with their average composition:

TABLE 7.

Giving the Approximate Amount of Phosphoric Acid in Fertilizing Materials.

Materials Containing Phosphoric Acid.	Phosphoric acid (P_2O_5). Soluble—Per cent.	Reverted—Per cent.	Insoluble—Per cent.	Total—Per cent.	Lbs. in one ton. Available phosphoric acid.	Total phosphoric acid.
Apatite,				38.0		760
Bone ash,				35.9		718
Bone black,				28.3		567
Bone black (dissolved),	16.0	0.7	0.3	17.0	334	340
Bone meal,	0.4	6.5	15.6	22.5	138	450
Bone meal (from glue factory),		6.5	22.4	28.9	130	578
Bone meal (dissolved),	10.0	5.0	2.5	17.5	300	350
Carribean guano,				18.9		378
Cuban guano,				17.9		358
Double super-phosphate,			4.0	44.0	800	880
Florida rock,				30.0		600
Florida soft phosphate,				24.0		480
Keystone concentrated phosphate,	0.3	38.2	9.2	47.7	770	950
Mona Island phosphate,		7.5	14.3	21.8	150	436
Navassa phosphate,				34.3		686
Orchilla guano,				26.8		536
Peruvian guano,	4.6	3.8	4.9	13.3	168	266
South Carolina rock (ground),		0.3	27.7	28.0	6	560
South Carolina rock (floats),		0.5	27.5	28.0	10	560
South Carolina rock (dissolved),	10.5	3.5	2.0	16.0	280	320
Slag phosphate (American),				21.0		420
Slag phosphate (German),				30.0		600
Tennessee phosphate rock,				35.0		700

SOURCES OF SUPPLY OF PHOSPHORIC ACID.

A study of the figures given in the preceding tables, particularly those of Table 4, leave but little doubt but that there must come a time with all soils, under normal conditions of cropping, when their natural contents of phosphoric acid will be much reduced, if not exhausted. This has been the experience of farmers the world over. Happily, nature made ample provisions for supplying all requirements for this valuable and essential plant food.

The first material used for furnishing phosphoric acid was bone, and the chief reliance was placed in this source for many years and even now it is very popular and furnishes a considerable percentage

of the amount used. But very soon it was determined that phosphoric acid was the chiefly valuable ingredient in bone and that phosphates were so essential for plant growth and development, it was pointed out by Professor Henslow, in 1845, in a lecture before the British Association, describing the Suffolk Coprolites, that these deposits of mineral phosphates could be of immense value for application in agriculture.

Even at this time large workable deposits of mineral phosphates were known to exist, they having been almost simultaneously discovered in several countries, notably those discovered by Buckland, in England, Berthier in France and Holmes in America (Ashley River, S. C., 1837), and since that time numerous other large deposits have been discovered in almost every part of the world, but those which are of special interest in the United States are those deposits of Florida, Tennessee and Virginia.

The mode of occurrence of the best-known deposits of phosphates of lime are quite erratic. They have been found in rocks of all ages and of nearly every texture. Sometimes they are very pure, sometimes their constituents are extremely variable. Sometimes they are found in veins, sometimes in pockets and again in stratified layers or beds, in connection with fossilized remains of all kinds deposited by ancient seas.

The supply of phosphates available for agricultural purposes may be divided, from a chemical standpoint, into two principal classes:

1st. Phosphates of lime or calcium phosphates.

2d. Phosphates of iron and alumina.

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(1) PHOSPHATES OF LIME OR CALCIUM PHOSPHATES.

For the manufacture of fertilizers and for agriculture purposes, phosphates of lime are generally preferred. This preference by the manufacturer is due to the physical characteristics of the compounds formed when treated with acid, and the preference on the part of the farmer no doubt has been moulded in a measure by the preferences of the manufacturers, yet, to a large extent, is probably due to the fact that bones are phosphates of lime, and they learned early to appreciate the good effects of bone and also in many sections recognized the great value of lime as a soil improver.

In this connection, there has been given a detailed description of the various sources of lime phosphates, and for their chemical distinctions, see under "Forms of Phosphoric Acid," on page 18.

SOUTH CAROLINA PHOSPHATES.

For the eastern farmer, the deposits of phosphates in South Carolina are by far the most interesting of any in the world, for they have done much towards increasing the productive capacity of many soils, and have made it possible to profitably farm very considerable areas that otherwise would have been abandoned. Their discovery has also, in a measure, revolutionized the agricultural pursuits of all parts of the world. The discovery of the deposits of phosphates in South Carolina is generally attributed to Prof. Francis S. Holmes, and probably rightly so, for it certainly was in connection with his work that the true character of these deposits were disclosed. Some make claims of the discovery for Dr. N. A. Pratt, and there is no doubt but that his work contributed toward demonstrating for the first time the true richness and value of the deposits. However, the existence of the deposits were known even before the date of Holmes' explorations, as is evidenced by the reference made to them as early as 1802 by Judge John Draton, but their practical value was not suspected. At that period marl or carbonate of lime was the valuable product, and these deposits were referred to by Mr. Ruffin, the State Geologist, as the "great Carolinian marl beds." Again, the attention of the people of Charleston was called to the fossil remains in that section, and to their similarity to the Coprolite deposits of England by the writings of an English tourist about 1820.

As these deposits have played so important a part in the agriculture of the Eastern States during the past thirty-five years, it may be interesting and not out of place to give a short sketch of the incidents relating to the discovery and the development of the deposits.

On the discovery of the deposits, Prof. Holmes, in "Phosphate Rocks of South Carolina," says:

"Some time in November, 1837, in an old rice field about a mile from the west bank of the Ashley river, in St. Andrew's parish, we found a number of rolled or water-worn nodules of a rocky material filled with the impression of marine shells. These nodules, or rocks, were scattered over the surface of the land, and in some places had been gathered into heaps, so that they could not materially interfere with the cultivation of the field. As these rocks contained little carbonate of lime (the material of all others then most eagerly sought after), the nodules were thrown aside and considered useless as a fertilizing substance. In a low part of an old field (Dec. 9, 1843), we attempted to bore with an augur below the surface to ascertain the nature of the earth beneath, with the hope of finding marl. On removing the soil above the rocks, they were seen in regu-

lar stratum about one foot thick, embedded in clay, and seemed to be identically the same as those found scattered on the surface of an adjoining field, all of them bearing impressions of shells, and having similar cavities and holes filled with clay. It was on the 23d or 24th of February, 1844, whilst engaged in the removal of the upper beds covering the marl, that the laborers discovered several stone arrow heads and one stone hatchet. Not long after finding these relics of human workmanship, and while engaged in our usual visits to the Ashley bed (marl), a bone was found projecting from the bluff immediately in contact with the surface of the stony stratum (the phosphate rock); we pulled it out, and, behold, a human bone! Without hesitation, it was condemned as an 'accidental occupant' of quarters to which it had no right, geologically, and so we threw it into the river. A year after, a lower jawbone, with teeth, was taken from the same bed. Subsequent events and discoveries show conclusively that the first described bone was 'in place,' and that the beds of the Post-Pliocene, not only on the Ashley, but in France, Switzerland and other European countries, contain bones associated with the remains of extinct animals and relics of human workmanship, proving most conclusively that the Carolina specimens were found in place, and as the European discoveries were made in 1854, and ours in 1844, to South Carolina should be awarded the honor of the first discovery.

"Whilst engaged in manufacturing saltpetre, on the west bank of the river, during the Confederate war, the lime or calcareous earth necessary in such operations was obtained by sinking pits into the Eocene marl bed. Upon the removal of a few feet of the upper layers the workmen discovered in one pit a number of oddly-shaped nodules, resembling somewhat the marl stones (phosphate rock) found in the stratum above the marl, but more cylindrical in form and not perforated, and having their exterior polished, as though each individual specimen had received a coat of varnish. They appeared to have been deposited in a large corner or pocket in the marl bed. These specimens were preserved and subsequently submitted to analytical tests, when their true value was revealed, and then began the practical work that demonstrated the fact that South Carolina possessed a deposit of phosphates the richest, perhaps, in the world."

So much for the discovery of the South Carolina phosphates. The commercial history and benefits flowing therefrom are full of interest to both business man and farmer.

On the development of the deposits, L. A. Ransom has given the following brief summary in the "Manufacturers' Record:"

"The beginning of the War of 1861 interrupted the investigations, then in progress by Mr. Ruffin, Professors Holmes and Pratt, Dr.

Shepard, Dr. St. Julien Ravenel and other scientific men. It was not until 1867, when reaction from the effects of the war began to set in, that attention was then directed toward the development of these deposits. In 1867, the Charleston, South Carolina, Mining and Manufacturing Company was organized to work the land deposits. A few Charleston and Philadelphia capitalists furnished the funds and Professor Holmes was elected President. The principal office was in Charleston, but a branch agency was established in Philadelphia. In 1870, the capital of the company was $800,000, and is at present $1,000,000. Many difficulties were met and overcome in this work, and much money was sunk, because the field of work was a new and untried one, and experience had to be gained by great loss of time and a large expenditure. In 1867, sixteen barrels of the rock were shipped to Philadelphia by Prof. Holmes for general distribution, and the first parcel of super-phosphates (commercial fertilizers) was manufactured by Messrs. Potts & Klett, of that city. The first cargo of 100 tons was shipped on the 14th of April, 1868, to Baltimore, Md., by John R. Dukes, president of the Wando Co., of Charleston." Prof. Holmes thus describes the reception of the rock in the markets: "The arrival of the first cargo in Philadelphia caused no little excitement in mercantile circles, especially among the manufacturers of fashionable fertilizers, and in a very short time after the chemists of that city, New York and Baltimore had pronounced it a true bone phosphate rock, the phosphate fever became epidemic in these cities."

The organization of companies to mine the river deposits followed close upon that of the land companies, the Marine and Oak Point mines being the pioneers. With the beginning of river mining, in 1870, the State, through the legislature, claimed control of the navigable streams, and by act of the assembly, imposed a royalty of $1.00 per ton on all rock removed from these streams. A charter was granted to the Marine and River Company, which gave it the exclusive rights to all the streams of the State upon the filing of a $50,000 bond and the punctual payment of royalty, quarterly. In 1870, three years after the commencement of mining operations, there were at work two river companies, five land companies and six companies manufacturing the rock into commercial fertilizers. The Marine and River Company leased a part of their territory to the Coosaw Mining Company, an organization composed of Baltimoreans and Charlestonians, and organized in May, 1870. This has been the most successful of all the river mining companies, because the most persistent. At the end of the first year's experience it had expended all its money and had nothing left except a dredge and some experience. Many of the parties interested favored suspend-

ing work, but largely through the influence of Mr. Robert Adger, the chief manager, operations were continued, additional capital raised and the result was the remarkable financial success already mentioned. Subsequent to the organization of the Coosaw Company, the Marine and River Company failing to comply with the terms of its grant from the State, forfeited its charter and retired from business, because they had found mining unprofitable. The Coosaw entered into new conditions and bonds directly with the State for the territory it had previously worked under permits from the Marine and River Company, in 1876, and continued work. After overcoming apparently insurmountable difficulties, employing the best talent for mining and marketing its product, it has rewarded its projectors, and paid handsome dividends to its stockholders.

The phosphate deposits in South Carolina are designated under the heads, viz: as "Land rock" and "River rock," according to the location in which it is found. These two classes vary some in physical characteristics, but not greatly in chemical composition.

The most prominent characteristic of the native Carolina phosphate is its nodular form. Even where the deposits occur as an apparently smooth and compact layer, or in large, flat cakes, it is, nevertheless, composed of irregular nodules, partially cemented or compacted together. Nearly all these nodules have the egg or kidney shape. The exterior is sometimes rough and indented, often honeycombed with irregular holes, and sometimes it is smooth and compact. The surface is occasionally shiny and coated, as if with enamel. Fossil shells, fish bones and teeth are not infrequently found imbedded in the nodules, and other animal remains occur in the same general deposits. The nodules vary in size from the fraction of an inch to several feet in diameter, and weigh from almost a ton downwards. When found, as much of this deposit is, in river bottoms or under marsh mud, the color of the material is a gray or bluish black. The land rock is usually of a lighter color, yellowish or grayish white. The masses are easily broken and ground to a fine powder, light yellow or gray, often becoming so fine as to float in the air. In this extremely fine condition, and before being treated with acid, the material is often called *Floats*. There is no reasonable doubt that these phosphates came from the remains of both marine and land animals, although it would be out of place to give the evidence here. A long series of geological transformations is involved, together with different eras of animal life, and subsequent changes in the mineral matters themselves. From several hundred analyses of the raw or simply ground Carolina rock, the mineral has been found to contain on an average from 25 to 28 per cent. of phosphoric acid—2.5 to 5 per cent. carbonic

acid, 0.5 to 2 per cent. sulphate acid, 35 to 42 per cent. lime and a little magnesia, soda, silica, iron and other elements. The finding of the fossil bones, teeth, etc., spoken of has led to the term "South Carolina bone," being incorrectly applied to these mineral phosphates.

DISSOLVED SOUTH CAROLINA ROCK.

Rock which has been treated with sulphuric acid to render the phosphoric acid soluble or available is termed Dissolved South Carolina rock. This constitutes by far the greater bulk of the materials now used in this country for making phosphate manures. An immense trade has grown up in this class of phosphates during the last thirty-five years. The most common name by which this class is known is "Acid Phosphate," but it is also found on the market as Dissolved S. C. Rock, Dissolved S. C. Bone and Bone Phosphate Rock. While the rock which was first used for making this class of fertilizers was first found in South Carolina, yet much of it now comes from Florida and Tennessee. The dissolved phosphates of this class contain a large portion of their phosphoric acid in the available condition, but not quite as much in the soluble form as in dissolved bone black.

DOUBLE SUPER-PHOSPHATE.

This, as its name indicates, is a concentrated form of soluble phosphoric acid. It is made by dissolving mineral phosphates in phosphoric acid instead of sulphuric acid. The process of manufacture consists of treating a low grade of phosphate rock, or those too poor in phosphoric acid to make a high grade or standard super-phosphate, with an excess of dilute sulphuric acid. This sets free the phosphoric acid, which, together with the excess of sulphuric acid, is removed and separated from the insoluble materials by filtration and washing. The acid solutions thus obtained are concentrated and then used for dissolving the better class of phosphate rock. Because the acids used for dissolving the phosphates contain phosphoric acid, the product yielded contains more than double the amount of phosphoric acid in the ordinary product.

Double super-phosphate is manufactured to some extent in this country, but mostly in Europe. Its use in this country is not as great now as it was a few years ago. This source of phosphoric acid, contains a minimum of impurities and a maximum of phosphoric acid in the soluble form.

SUPER-PHOSPHATE.

This was the name originally given to a fertilizer which had been treated with acid to render the phosphoric acid soluble, but in after

years it came to be commonly applied to all classes of fertilizers rather indiscriminately, especially to all those which had a dissolved bone or rock as a base, even if some nitrogen or potash had been mixed with it. To overcome this difficulty the term "Plain Super-phosphate" came into existence to designate a dissolved phosphate which contained only phosphoric acid.

FLORIDA PHOSPHATES.

These phosphate deposits are of two general classes, viz: The phosphates of lime and the phosphates of iron and alumina.

The Florida deposits, perhaps, have more commercial interest at this time than those of South Carolina, as a large part of all the rock fertilizers on the market are manufactured from the Florida goods. There is very little difference in general composition and characteristics between the deposits of these two States, except that perhaps more of that from Florida runs smaller in size, so that it is popularly designated "Pebble Phosphates." There are both river and land deposits of these pebble phosphates, as well as the land rock phosphates. Florida phosphates were discovered in the winter of 1881 by Francis LeBaron, a member of the United States Army Engineer Corps, while surveying a canal route from the headwaters of the St. Johns river, in South Florida, to Charlotte Harbor. Mr. LeBaron did not make the discovery public, but recognized the importance and value of the "find," and confided the matter as a secret to a few wealthy gentlemen. These capitalists were timid, if not skeptical, and so did nothing. The public was not apprised of the existence of the phosphate depoists until 1888, and even then it excited but little interest, for it was thought that the deposits were small and confined to a limited area.

In 1888, Mr. T. S. Moorehead, of Pennsylvania, followed up the discovery of LeBaron—information of which he had obtained in some way—and acquired possession of some of the richest of the Peace river deposits and started mining in a small way. He made the first shipment of phosphates that ever went out of Florida in May, 1888, and the total shipment for that year was only 2,000 tons.

It is interesting to note that with the Florida deposits, as with those of South Carolina, the first capital for the development was ventured by people from Pennsylvania.

TENNESSEE PHOSPHATES.

The deposits of phosphates in Tennessee, from a commercial and agricultural standpoint, to-day are next in importance to those of the two States mentioned above. The deposits in Tennessee were discovered in 1894, and they have been extensively explored and

rapidly developed since that time. These deposits differ from those of South Carolina and Florida in that it does not exist as pebbly nodules or bowlders, but in veins and pockets. The deposits vary in composition, yet many of the veins are very rich and relatively pure phosphate of lime. This makes them a valuable source of supply for the manufacturer.

PENNSYLVANIA PHOSPHATES.

The deposits of phosphates in Pennsylvania, as far as known at the present time, are not very extensive, yet they give promise of assuming some importance. Mr. T. S. Moorhead, of Port Royal, president of the Tuscarora Valley Railroad, was probably the first to call public attention to the existence of phosphate rock in Pennsylvania, in 1895. He sent numerous specimens of these deposits to the Pennsylvania Experiment Station for examination, and a detailed report of as much as was known of the extent and character of the deposits up to that time was made in 1896, in Bulletin No. 34, of that Station.

Three classes of phosphates have thus far been discovered. The first, a friable white rock, locally known as "white vein," and contains from 29 to 54 per cent. of bone phosphate. The second consists of red nodules and contains considerable iron and alumina and an equivalent of from 45 to 52 per cent. of bone phosphate. The third occurs in blocks which resemble blue limestone, and contains about 40 per cent. bone phosphate of lime. Eight feet is the thickest vein discovered as far as reported.

While these materials are of much lower grade than the phosphates of South Carolina, Florida and Tennessee, yet it is of considerable importance, locally, and will be valuable for shipment to nearby points.

Some idea of the amount of phosphate rock consumed annually, can be gained from the following figures, which give the amounts mined in the different States during the year 1900:

Region.	Long Tons.
Florida,	582,900
Tennessee,	436,000
South Carolina,	562,000
North Carolina,	15,250
Pennsylvania,	3,750
Total,	1,599,900

VIRGINIA PHOSPHATES.

The Virginia deposits are attracting more or less attention at this time, but they have not been extensively developed. They are not unlike those of South Carolina in general composition, though they contain rather more iron and less phosphoric acid.

APATITE.

Apatite is the name given to a mineral phosphate of lime found in numerous localities. It occurs in the State of New York and in very large masses in different parts of Canada. But, as usually found, it is exceedingly hard and difficult to grind, besides being badly mixed with other and worthless minerals. These objections have prevented apatite from being extensively used in the manufacture of fertilizers, although it is rich in phosphoric acid, sometimes containing as much as 40 per cent.

CAPROLITES.

Caprolites, or coprolites, resemble, in most respects, the nodules of the American phosphate deposits, but average smaller and more even in size, ranging from one to four inches in diameter. They are not common to this country, but are found in England and France in quantity and are there used for making commercial fertilizers by the thousands of tons. They are believed to be the dung of extinct animals, changed into a mineral form and worn by water into their usual kidney shape. They also contain other animal remains, such as teeth, scales and fish bones. They show, by analysis, 25 to 30 per cent. of phosphoric acid.

PHOSPHORITES.

Phosphorites are another form of mineral phosphates closely allied to apatites, and found in France, Germany and Spain, where they are of commercial importance as fertilizer material.

There are extensive deposits of phosphatic substances in England, France, Belguim and Russia, not especially described, because having little effect upon the supplies of phosphates for America.

SLAG PHOSPHATE.

Slag phosphate, Basic iron slag or Thomas slag-meal—to these names may be added *Thomas Scoria* and *Odorless phosphate*, all given to a waste material or slag, which is a by-product in the preparation of steel, by what is known as the "basic process." The object of this process is the extraction of phosphorus from pig iron, by means of a basic lining of the converter invented by Jacob Reese. The

product of the process is a substance containing 15 to 20 per cent. of phosphoric acid. It is metallic in appearance, but may be ground, forming a dark brown meal. The phosphoric acid is in combination chiefly with lime, as tetra-calcium phosphate; it is insoluble in water, slightly soluble in ammonium citrate, and is, by ordinary methods of analysis, classified largely as insoluble. Yet its condition is such that soil water, when charged with carbonic acid, will dissolve it to a considerable degree. Thomas slag is largely used and highly valued in Germany, and is the cheapest form in which phosphoric acid can be obtained by the farmers of that country. Wagner states that two compounds of this material, ground fine (but no acid treatment), containing 18 per cent. phosphoric acid and no other valuable plant food, and costing four and one-half cents, produces the first year after its use, the same increase in yield as one pound of soluble phosphoric acid from bone meal costing six and one-half cents. And in the second year the effect of the Thomas slag was twice that of the other. These are important facts, but the place of this slag phosphate among the commercial fertilizers of this country has yet to be determined.

This material gets the name, by which it is best known in Europe, from S. G. Thomas, of England, who claimed to be the prior inventor of the basic process of making pure steel. This claim was disputed by Jacob Reese, of Pennsylvania, and the courts of this country have confirmed the claim of Reese. The slag is now manufactured by the latter in large quantities at Pottstown, Pa., and is sold under the name of Odorless Phosphate. This is the slag very finely pulverized, but not treated with acid. An idea of the growth of the consumption of slag phosphate may be gotten from the following report, showing its production:

TABLE 8.

Slag Phosphate Produced.

Year.	Tons.
1878,	4
1879,	860
1880,	15,000
1881,	100,000
1882,	135,000
1883,	190,411
1884,	259,000
1885,	283,435
1886,	412,605
1887,	511,244
1888,	585,970
1889,	682,365
1890,	783,924
1891,	720,134
1892,	800,660
1893,	874,000
1894,	896,301
1895,	9[illegible]4,235
1896,	962,050
1897,	1,033,002
1898,	1,105,000
1899,	1,250,120
1900,	1,462,325
1901,	1,700,000

BASIC SUPER-PHOSPHATE.

This is a class of super-phosphate that was introduced in the English market in 1900. It is made up of a mixture of slaked lime and ordinary super-phosphate. The idea that led up to the making of this mixture was caused by an effort to produce an alkaline phosphate with some of the characteristics of slag phosphate, but one which would also give results on sandy and other soils that were deficient in organic matter. This basic super-phosphate can also be used on soils which are acid and upon which ordinary super-phosphate (acid phosphate) gives poor results. In fact, the claim is made for it that it possesses all the advantages of both slag phosphate and of acid phosphate.

The following laboratory experiments* show the relative solubility of basic slag phosphate and the basic super-phosphate:

*Experiments of John Hughes, originator of the basic super-phosphate.

Solubility in Cold Water After 48 Hours. (1 part phosphate to 1,000 parts cold water.)	Basic super-phosphate.	Basic slag.
Portion soluble in cold water,*	66.80	6.60
Portion insoluble after ignition,	33.20	93.40
	100.00	100.00
Containing:*		
Soluble lime,	22.28	4.70
Phosphate of lime,	None.	None.

These figures show the basic super-phosphate to have ten times as much matter soluble in pure cold water as the slag phosphate, and may indicate the reason for slag phosphate not acting on soils which are lacking in vegetable matter. Nevertheless, it will be noted that there was no phosphate dissolved by the water from either substance.

The solubility in weak acid solution was as follows:

Solubility in (1 in 1,000) Citric Acid Solution After 24 Hours. (1 part in phosphate to 1,000 parts solution.)	Basic super-phosphate.	Basic slag.
Portion soluble in citric solution,*	94.20	38.80
Portion insoluble after ignition,	5.80	61.20
	100.00	100.00
Containing*		
Soluble lime,	34.73	22.17
Soluble phosphoric acid,	12.45	8.70
Equal to phosphate of lime,	27.18	18.99

Basic super-phosphate is probably made by mixing one part of finely ground or slaked lime with three parts of plain super-phosphate or dissolved or acid phosphate.

Basic super-phosphate is not unlike, in some respects, to the non-acid phosphate which was manufactured in Baltimore a few years ago under the Hoskin patents.

RAW BONE, GROUND BONE OR BONE MEAL AND DISSOLVED BONE.

Animal bones are composed of two distinct substances, which interpenetrate one another. There is a sort of frame-work of earthy matter, which is a substance containing much nitrogen. Raw bones are, therefore, doubly valuable for manurial purposes, because they contain both phosphoric acid and nitrogen. As ordinarily collected, bones contain from 50 to 60 per cent. of phosphate of lime and from 5 to 7 per cent. of nitrogen. Fresh raw bones also contain fat, and this is not only useless as a plant food, but it adds weight to the bone and makes it hard to grind, and, when ground, the more fat remaining in the bone the slower will be the decomposition in the soil. To obviate this difficulty, bones are generally steamed, or carried through some process to remove the fat, before they are ground for fertilizers. Steamed or dessicated bones, if not too strongly steamed, are better for fertilizer than raw bones. Some nitrogen is lost by this process, but if carefully done, the gain exceeds the loss. Bone meal is obtained by grinding the crude or steamed bones, and it is valuable in proportion to the degree of fineness to which it is reduced. According to its fineness, it is variously called ground bone, bone meal, flour of bone and bone dust. The finer it is, if used without acid, the easier it decays or dissolves in the soil, and the sooner the chemistry of nature converts the (tri-calcic) phosphate of lime to a form available to plants. Good ground bone or bone meal should contain from 20 to 25 per cent. of phosphoric acid and from 3 to 4 per cent. of nitrogen.

The demand for bones for use in various arts and especially in refining sugar, is making this form of fertilizing material comparatively scarce in the market and correspondingly high in price. If rates advance much, it will become unprofitable for farmers to use bone fertilizers for their phosphates. The same causes lead to the considerable adulteration of bone meal that is now found. Lime, gypsum, coal ashes, ground oyster shells, crab shells and like articles are used for this purpose as well as the less objectionable mixing of fine-ground rock phosphate, all being sold under the name of bone. When bone, ground bone or bone meal is treated with sulphuric acid, the product is the dissolved bone of our markets, also known as acidulated bone, soluble bone and dissolved bone phosphate. This is simply an acid phosphate or super-phosphate, made from bones.

BONE BLACK AND DISSOLVED BONE BLACK.

When broken bones are placed in a retort or iron cylinder, the air being excluded, and then strongly heated, gas, water, oily matters and other products are driven off, while black bone charcoal is left.

This product, also known as bone black and animal charcoal, is used extensively in sugar refineries for taking the coloring matter out of raw sugars. From time to time portions of the bone charcoal cease to be effective in clarifying and the spent black is then sold by the refineries for fertilizing purposes. All the phosphoric acid originally in the bones is retained, but the presence of carbon prevents the phosphate from decomposing. It is as "dissolved bone black" that this article is generally found on the market. Dissolved bone black contains a large proportion of soluble phosphoric acid and a very small amount in the insoluble form.

BONE ASH.

The supply of bone ash comes mainly from South Africa, where the bones of animals are used as fuel in extracting the fats from the carcass. In the process of burning, all the organic matter is destroyed, so that the nitrogen of the bones is lost. Bone ash contains from 30 to 35 per cent. phosphoric acid, and in a form so insoluble that this material is little used as a fertilizer until it has been treated with acid.

At one time this source supplied considerable phosphoric acid and was found on all markets, but at the present time little or none is to be found.

PRECIPITATED BONE OR PRECIPITATED PHOSPHATE.

Every year large quantities of bones are treated with hydrochloric (muriatic) acid for the purpose of dissolving the mineral matters of the bone and of obtaining their ossein for use in the manufacture of gelatine. To the clear solution of phosphate of lime in hydrochloric acid thus obtained is added enough milk of lime to neutralize the acid and precipitate the phosphate. The precipitate is in the form of a very fine powder and may be used directly for fertilizing purposes, or it is sometimes treated with sulphuric acid to render the phosphates soluble as, precipitated, this material contains, on the average, about 18 or 19 per cent. of phosphoric acid.

There is also some precipitated phosphates that come from other manufacturing sources.

BONE TANKAGE.

Tankage is the residue remaining in the tanks used for boiling cattle heads, feet and all sorts of slaughter house refuse.

Bone tankage represents an important source of phosphoric acid. It is so closely related to raw bone or steamed bone as far as its contents of phosphoric acid are concerned that it is not necessary to say more here on that point. Tankage is also quite available as a source of nitrogen or ammonia in making mixed fertilizers. There

are six grades of bone tankage recognized in the trade: 1st grade, containing 18 or 19 per cent. of phosphoric acid; 2d grade, 16 per cent. phosphoric acid; 3d grade, 13½ per cent. phosphoric acid; 4th grade, 11½ per cent. phosphoric acid; 5th grade, 9 per cent. phosphoric acid, and 6th grade, 7 per cent. phosphoric acid. The nitrogen of tankage increases as the percentage of phosphoric acid decreases.

OTHER ORGANIC SOURCES OF PHOSPHORIC ACID.

There are numerous other sources of phosphoric acid which may all be included in the class of refuse or by-product materials. Dried fish, which contains about 7 or 8 per cent. of phosphoric acid, is the most important of this class. Cottonseed meal and castor pomace are also important sources of phosphoric acid.

PHOSPHATIC GUANO.

There are two classes of phosphatic guanos; those which are largely lime phosphates and another class which are largely iron and alumina phosphates. Both these classes are called guanos because they resemble one another very closely in general appearance, and were probably of the same origin. These guanos were formed from the dung of birds. The Peruvian guano was the first to come into general use and it gave remarkably good results, but it contained some nitrogen and potash, as well as phosphoric acid. The other phosphates of this class, while resembling the Peruvian guano much in appearance, yet were formed in rainy regions, which washed out the nitrogen and potash of the original dung. The following are the principal phosphate of lime guanos: Baker Island guano, which contains 65 to 85 per cent. of lime; Howlands Island and Jarvis Island are both nearly as good. These three islands are in the Pacific ocean. Majellones and Patagonia phosphates are both rich in phosphate of lime, and also contain some nitrogen. The Mona Island, Navassa and Orchilla guanos contain considerable phosphate of lime, but also have a marked per cent. of iron and alumina phosphates, which places them in the latter class as far as their value for manufacturing purposes is concerned.

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(2) IRON AND ALUMINA PHOSPHATES.

Very large deposits of phosphates of iron and alumina have been discovered in many places of the West India Islands. They were at first mistaken and shipped in large quantities for phosphate of lime. Upon complete analysis their true nature was determined, and because they were unsuitable for the manufacture of super-phosphates, giving, when treated with sulphuric acid, a sticky mass

which was hard to handle, to dry and prepare in a good mechanical condition, they were denounced by many chemists as valueless for fertilizing purposes.

The chemists, in stating that this class of phosphates was valueless for fertilizing purposes, evidently went a step too far, for they should have said that they were not suitable for the manufacture of super-phosphates. It is a notable fact, which some chemists evidently overlooked, that the phosphoric acid which is found naturally in the soil exists largely in the form of iron and alumina phosphates.

While this class of phosphates are not adapted for making super-phosphates and, consequently, are unpopular with the manufacturer of chemical fertilizers, yet it must be admitted, in the light of results of numerous experiments, that they are valuable in the raw state, if finely pulverized, as a direct fertilizer.

The following analysis gives a fair idea of the composition of this class of phosphates:

	Per cent.
Moisture,	12.36
Water of combination,	4.13
Phosphoric acid,*	30.22
Lime,	4.16
Magnesia,	Trace.
Oxide of iron,	7.04
Alumina,	24.00
Carbonic acid,	None.
Sulphuric acid,	None.
Fluorine,	Trace.
Insoluble matter, sand, etc.,	18.09
	100.00

*Equal to 65.87 per cent. of tri-basic phosphate of lime.

FLORIDA SOFT PHOSPHATES.

This is probably the most important alumina and iron phosphate to the States of the Atlantic ocean border at the present day, both from an agricultural and commercial standpoint. There is considerable deposits of this class of rock in Florida. It is known as soft phosphate because of the ease with which it is broken up and pulverized. As has been said, it is not well adapted for treatment with acid for making soluble phosphates, as the alumina and iron make a sticky mass which is hard to dry and keep in a good mechanical condition. Hence, it has not been mined extensively or had a large sale. Locally, this soft phosphate has had extensive use in its natural condition. Its application has given good results on sandy land, which had been given heavy dressings of the native

swamp and lake muck. This muck furnishes nitrogen as well as the much-needed organic matter. These phosphates have also given good results on the "hammock lands."

ALUMINA AND IRON PHOSPHATE GUANOS.

As has been already mentioned, there is a large class of phosphates which are derived from the dung of birds and sea fowls, which go under the term of guano. These phosphates have more the appearance of earth than of organic products. As originally formed, of course, these were mostly phosphates of lime, but through the action of the water, in conjunction with the rock and soil characteristics of the islands, the lime has been replaced by alumina and iron. Most of the phosphates from the islands off the coast of South America and from the West India and Caribbean Islands belong to the alumina and iron class.

They are popularly known under the name of the island on which they are found, and the principal ones which are met with in agricultural literature and trade are as follows: Alta Vela, Caribbean, Cuban and Redunda phosphates or guanos, besides the Mona Island, Navassa and Orchilla guanos already mentioned.

THE USE OF PHOSPHATES.

There seems to be but little doubt as to the need for the application of phosphates when the amount that is being taken out of the soil annually by crops is considered. It has been seen from the matter on the preceding pages that there is an abundant supply of phosphoric acid to draw from, and in quite a variety of forms, so that it would seem possible to be able to comply in this respect with almost every requirement of the soils and crops which might be presented. While most farmers seem to be aware that there is a variety of sources of phosphates, yet they have not come to give that consideration to the other phases of the subject as would seem desirable in order that the different phosphates might be used most intelligently or with more profit. In this connection, the following questions immediately arise in the minds of the farmer:

1st. Under what conditions is it possible to essentially increase the returns from the soil by the application of phosphates?

2d. What kind of phosphates shall be used?

3d. How shall it be used or applied?

4th. How much shall be used?

These are all natural questions and ones to which every farmer could well give more study. The first point to study in the consideration of the question of the application of phosphates is the

same that arises in connection with the use of any fertilizer, and that is as to the consideration of the particular soil in question and its requirements.

The cause for small returns from land is not always a lack of plant food, consequently this is the first point to be considered. Often the plant suffers from either one or a combination of the following troubles:

1st. Gets thirsty from an insufficient supply of water.

2d. The soil is not properly aerated.

3d. From an insufficient porosity of the soil, whereby root development is checked.

4th. From caking of the soil, which works harmfully and locks up plant food.

5th. From the soil being impenetrable, which makes the soil wet, with all of its attendant evils.

6th. From lack of humus or organic matter and, hence, the soil is heavy and lifeless.

7th. From the soil being acid, which prevents normal plant development and especially the growth of the beneficial micro-organisms of the soil.

8th. Occasionally in the east, and often in the west, the soil is overcharged with soluble salts, which prove harmful.

In short, there are many physical and chemical relations of the soil or unfavorable conditions of the health of the plant which exert an injurious influence on the proper development of the plant, and, hence, cut down the yield.

In such cases, the plant seldom has need of a large addition of food, and the first step toward an improved yield is to seek the difficulty and correct that before considering what plant food to supply and how to supply it.

There are many ways open to correct the difficulties enumerated above, such as irrigation, drainage, deep culture, better plowing, more thorough harrowing and pulverization, mucking, liming, marling, etc. It is only by fully utilizing these means that the land will be in shape to receive artificial applications of plant foods, and that crops may use and benefit by such applications. In fact, applying artificial plant foods under many of these adverse conditions actually works harm instead of good. Deep, well-tilled, well-drained, non-acid loam containing a fair amount of organic matter or humus, and under good weather conditions, offers the best circumstances for a sure effect from the application of phosphates or any other plant food, and every means which improves these conditions will contribute towards the success of such applications.

How much phosphate to apply, as with other plant foods, will depend upon the requirements of the crops grown with reference to the soil in question.

Luxuriant plant growth or large crops and intensive soil culture are synonymous with the rapid conversion of plant food into crops. The demand for plant food must, therefore, be greatest where the consumption is greatest as will be indicated by the yield of the crop. This demand must be supplied, either from rendering the natural plant foods of the soil available or else they must be supplied through artificial applications. Hence, the quantity of phosphoric acid to apply must be regulated with reference to the natural soil supply and the requirements of the crops being grown.

From what has been said it must not be inferred that phosphoric acid can only be applied advantageously on the better grades of soils. This would be absolutely incorrect, for under favorable circumstances relatively larger results are secured from the application of phosphates on poor and even neglected and exhausted soils, but in such cases the applications should be made with greater precaution and intelligence as the conditions are more special and entail greater risks than on soils in better condition.

The points as to what kinds of phosphates to use in particular cases and how to use it, will develop in connection with the discussion of different phases of the subject as presented in the subsequent pages, and each person will need to study this portion of the subject and make such application as may seem best under the particular circumstances with which it is being dealt.

POINTS AFFECTING THE AVAILABILITY OF PHOSPHATES.

The form in which phosphoric acid offers the best all-round advantage to the practical farmer is a very delicate and difficult one to determine. Reasoning on the basis of the generally admitted theory that all elements must be in solution before they can enter into the interior of plants, it would then naturally follow that preference will be given to those phosphates which are most readily soluble or subject to dissociation. This will depend principally upon two conditions

1. The form and general characteristics of the phosphate.

2. The nature and composition of the soil to which the particular phosphate is applied.

In general, phosphates with the same chemical and physical characteristics are equally valuable when used under like conditions, no matter from what source they have been obtained. The many factors which enter into the availability of phosphates can be con-

sidered more in detail in connection with the results of some experiments treated of later in this bulletin, but a brief summary of the principal points will be given in the following paragraphs.

THE INFLUENCE OF THE CHARACTER OF THE SOIL UPON THE AVAILABILITY.

The kind and character of the soil may influence the ease and rate at which plants may be able to use the phosphate which is applied. A soil which is open and porous, and which admits of a free circulation of air and water, presents more favorable conditions for the crops using the phosphates than on a close, compact soil.

There is a marked difference in the availability of phosphate dependent upon the origin of the soil, and, hence, upon the chemical and physical properties. Many phosphates will act well on clay soils that are poorly adapted to the sandy soils, and some difference is manifestly due to the different chemical properties of various clay and sandy soils, dependent upon their origin.

THE EFFECT OF ORGANIC MATTER UPON THE AVAILABILITY OF PHOSPHATES.

Organic matter exerts a marked influence upon the physical properties of a soil and, hence, in this way alone, may aid in making applications of phosphate available. The formation of humic acid and humates also works beneficial results. Again, the organic matter is constantly undergoing more or less decomposition and thus giving off carbonic acid gas, which unites with the soil water. Water so charged has a greater dissolving action upon phosphates than ordinary rain water, hence, the presence of organic matter may render many phosphates available which would be entirely useless in the same soil without the organic matter.

Some experiments conducted by Bretschneider to determine the relative solubility of some phosphates in pure water and water charged with carbonic acid show that one part of phosphoric acid was dissolved in the several substances as follows

	Parts of pure water.	Parts of carbonic acid water.
Precipitated tri-calcium phosphate, fresh,	87.832	13.181
Precipitated tri-calcium phosphate, ignited,	159.382	13.324
Precipitated di-calcium phosphate, fresh,	29.350	8.916
Ammonia and magnesia phosphate,	21.957	1.969
Precipitated iron phosphate, fresh,	160.625	146.570
Precipitated iron phosphate, ignited,	732,958	732.958
Bone black finely powdered,	....	249,480

Several investigators have tested the solubility of rock phosphates in humic acids and in humates of ammonia, and it has been shown that the humic acids have really a considerable solvent power for phosphates, which would seem to explain the good effects produced by certain phosphates on peaty or muck soils.

INFLUENCE OF THE KIND OF CROP UPON THE AVAILABILITY.

The root system and habit and periods of growth vary considerable in different classes of crops, and hence their ability to get at and use plant foods, which accounts for some crops using insoluble phosphates more readily than others.

For instance, some experiments seem to show that turnips possess to an especial degree the ability to feed upon undissolved phosphates, while potatoes seem to have but little ability in this direction.

THE INFLUENCE OF THE SOURCE OF THE PHOSPHATE UPON ITS AVAILABILITY.

As has been stated, the availability of a phosphate depends upon the source and the relation which it bears to the soil, the crop and the conditions under which it is applied. So that phosphate which is available under one condition may be unavailable under another.

If the availability of the phosphate used depends upon the changes which take place after it is applied to the soil, it will generally be found that organic phosphates will act quicker than those of mineral origin, as all organic matter is subject to decay and thus responds to the action of the natural agencies which exist in most cultivated soils. While the mineral phosphates are fixed and more or less stable compounds, which, if not natural food for crops become so but slowly, as they yield very gradually to chemical changes.

When the material is being used in a dissolved condition it makes but little difference whether it is derived from the animal or mineral source.

THE AVAILABILITY AND LASTING EFFECTS OF PHOSPHATES AS DETERMINED BY MECHANICAL CONDITION OR DEGREE OF FINENESS.

The finer or more highly sub-divided a material is the greater surface it presents and, hence, the more easily is it acted upon by either organisms of decay or dissolved by the soil water, or the solution sent out by the roots of plants for the purpose of preparing plant food.

The finer the material the more easily is it disseminated in the soil and consequently placed in better position to be used by plants.

The chief ultimate value, as explained elsewhere, in reducing the phosphate to a soluble condition is the fine division and great dissemination which they get in the soil by being reverted or precipitated.

There is no particular classification of most phosphates, particularly the dissolved goods, with reference to mechanical condition, but with raw bones all fertilizer controls adopt a standard of fineness and base the valuation accordingly. The following are the standards and values in common use at this time:

Standard of Fineness.	Value of Phosphoric Acid.
Fine, less than 1-50 inch,	5 cents per pound.
Medium fine, 1-25 to 1-50 inch,	4 cents per pound.
Medium, 1-12 to 1-25 inch,	3 cents per pound.
Coarse, larger than 1-12 inch,	2 cents per pound.

In the early days of the use of bones as fertilizers they were applied in a very coarse condition, but as their use grew they were made finer and finer, until, in some cases, they were reduced to an impalpable powder. To reduce the bone to powder is too expensive, but now, in most cases, they are ground quite fine. Considerable study of the question of the rapidity of the availability of bones and phosphates has been made in Great Britain in connection with the tenant system of that country, so that due credit could be given for the amount remaining in the soil a given period after application with the various systems of farming. The degree of fineness of bones was an important factor in this valuation.

THE LIMING OF LAND AND ITS EFFECT UPON THE AVAILABILITY OF PHOSPHATES.

There has been considerable said from time to time upon this point, and there seems to be considerable difference of opinion expressed. No doubt there are some soils and circumstances which will produce directly opposite results when the land is limed either directly before or after the application of phosphates. The opinions expressed as a result of the first experiment conducted by the French chemists upon this point were to the effect that lime and phosphates were incompatible, as the soil water had a greater dissolving action on carbonate of lime than on phosphates, so prevented the crops using the phosphate. Be this as it may, there seems to be but little evidence that such is the result in practice, as in very many cases increased yields follow such combinations. This opinion seemed to be substantiated to the greatest extent on the soils already rich in carbonate of lime. On soils that are deficient in lime there seems, on the contrary, to be a benefit from the use of lime and phosphates in conjunction. While it is doubtful if these should be applied either at the same time or very close together,

yet if there is a reasonable time elapsed after the application of the lime and the lime had been thoroughly incorporated with the soil before putting on the phosphate it would seem from theory and also from the results of practice that the lime would aid in the forming of more desirable compounds with the soluble phosphoric acid than would be formed by a union of phosphoric acid with either iron or alumina. Again, on land that has been limed, the precipitation or reversion of the soluble phosphates would take place promptly and thus prevent harm that might come from the acid condition of the soluble phosphates when they come in close contact with young tender roots of plants and germinating seeds.

HOW SHALL PHOSPHATES BE APPLIED, BROADCAST OR IN THE HILL OR DRILL?

The question is frequently asked as to how phosphates and, in fact, fertilizers in general, should be applied. From what has already been said on the point of the desirability of thorough dissemination of phosphates of all sorts and of getting the soluble phosphates incorporated with the soil so that reversion shall promptly take place, and not subject the young and tender rootlets to injury from the acid and soluble phosphates, it would seem that there should be but little doubt but that the best way to apply phosphates would be to broadcast them and to have the broadcasting done so as to get as thorough a distribution as possible.

Again, in the case of the soluble, or acid phosphates, the principal value ultimately gained by the treatment with acid is the obtaining of the phosphates in a very finely divided state and getting it widely disseminated. The full value of these points is only obtained by broadcasting the fertilizer.

There is still another and very important point to consider in this connection, and that is the means by which plants feed. Plants obtain their food through the roots and the most active roots are the young and fibrous ones. A study of the root systems of all our common plants will be a great surprise to anyone who makes the study or examination for the first time. The area and depth covered by the roots of all our plants will astonish most farmers who have never considered the matter. When corn is but six or eight inches high the roots of the plant will often be found to be extended out two or three feet in all directions, or to be running from row to row and going much deeper than is ordinarily plowed. The roots of a tobacco plant will almost always cover two or three time as great a surface as the leaves of the plant can shade. Even the roots of potato plants before maturity will extend from row to row under the common system of planting.

Now, taking these facts as to the root system into consideration, it would seem to present another strong argument in favor of broadcasting the fertilizer. Wide distribution also brings the phosphates in contact with a greater amount of soil waters and thus increases their availability. In case of raw bone, broadcasting would favor decomposition and the natural agencies for rendering it available. Putting bone, acid and other organic fertilizers in the hill will often produce fermentation that will kill the germinating seed.

There are times and circumstances, however, when it probably would be advantageous to apply phosphates, or even other fertilizers in the hill or drill. Such cases would probably be caused by the following considerations:

1st. When very small quantities were being used and it was only desired for the purpose of giving the crop a rapid start, while the natural fertility was sufficient for growing a good crop after it was well started.

2d. Under some circumstances the application in the hill or drill would have a tendency to retard the reversion of the soluble phosphates and thus keep it for a longer time in a form more available to certain crops. This consideration may obtain in some cases with such crops as potatoes.

3d. The application of small quantities of phosphates and other fertilizers (particularly kainit) will sometimes protect plants from cut worms and root lice in the early stages of their growth.

Putting fertilizer in the hill has been likened to a man sitting down on his dinner pail and then reaching out for his dinner in all directions, but there is no doubt that in some cases and with some plants it is just as easy for the roots to reach and feed on the fertilizer in the hill as it would be for a man to utilize the dinner under such circumstances.

Taking everything into consideration, it would probably be best, under ordinary circumstances, to always apply phosphates broadcast and only put it in the hill when guided by special conditions.

THE AGRICULTURAL AND COMMERCIAL VALUE OF PHOSPHATES.

Notwithstanding the numerous explanations that have been made in the agricultural press, in bulletins and by lecturers at farmers' institutes, etc., of the difference between the agricultural value and the commercial value of fertilizers, farmers are continually confounding the two values, and falling into the error that because one fertilizer has a higher commercial value than another it must necessarily have a higher agricultural or fertilizing value as well.

The commercial value of a fertilizer depends upon its abundance, the ease with which it is produced and the amount being

used, or, in other words, upon the ever-ruling elements in the commercial world of "Supply and Demand."

The agricultural value depends upon the ability of the particular fertilizer or phosphate in question to improve the fertility or productive capacity of a particular soil. Hence, it will be seen that the agricultural value, within certain limits, is not directly dependent upon the commercial value (and vice versa), and is a value that changes with different soils.

To illustrate; suppose a particular class of soils contain all the phosphates necessary for crops and that the application of any more phosphates give no returns whatever in increasing yields. This would mean that for that particular piece of land phosphates had *no value agriculturally*; yet that would not affect the market or commercial value of the phosphate. To illustrate further; sugar has a commercial value of $100.00 per ton, while Dissolved South Carolina rock can be purchased for one-tenth that sum. From a fertilizing standpoint, it is doubtful if an application of sugar would have any effect on the yield of crops, while the phosphate might double them, and thus have double the agricultural value of the sugar. Again, clover hay, for instance, has double the fertilizing and feeding value of timothy hay, yet the commercial or market value of timothy hay is always the more.

The following is the commercial value of phosphoric acid in different phosphatic materials according to the trade valuations in Pennsylvania in 1901:

	Cents per pound.
Soluble phosphoric acid in bone fertilizers,	5
Soluble phosphoric acid in rock fertilizers,	3
Reverted phosphoric acid in bone fertilizers,	4½
Reverted phosphoric acid in rock fertilizers,	2½
Insoluble phosphoric acid in bone fertilizers,	2
Insoluble phosphoric acid in rock fertilizers,	1½
Total phosphoric acid in fine raw bone, tankage and fish fertilizer,	3½
Total phosphoric acid in medium bone and tankage,	3
Total phosphoric acid in coarse bone and tankage,	2½
Total phosphoric acid in cotton-seed meal,	4
Castor pomace and wood ashes,	4

From these figures it will be seen that the commercial or trade value of 100 lbs. of soluble phosphoric acid in a dissolved bone would be $5.00, while 100 lbs. in a dissolved rock would be but $3.00. From an agricultural standpoint, in view of all the experiments which have been conducted, the value of phosphoric acid from the two sources would be exactly the same.

Again, the above valuations place a higher valuation upon the total phosphoric acid in cotton-seed meal than that from bone, whereas, when applied, probably there would be no difference so far as phosphoric acid is concerned.

From what has been said it would be plain to every farmer that he should buy a phosphate or, indeed, any fertilizer with reference to the value it has to him in increasing the productive capacity of his soil and not purchase solely upon the basis of commercial valuations as represented by agents or tabulated analysis of fertilizers.

THE DETERMINATION OF AVAILABLE PHOSPHORIC ACID IN SOILS.

The purpose of the agricultural chemical examination of soils, from the earliest time when the science was employed in this way, was to throw some light upon the relations of the various constituents to plant growth and especially to determine the amounts of the essential constituents which are in a condition to be used by crops or, in other words, "available." There have been numerous methods proposed for distinguishing between available and unavailable plant foods in various kinds of soils, and this problem has occupied the attention of the best minds in agricultural chemistry for many years. No one element in this study has received as much attention as the phosphoric acid.

At the present day there seems to be a general agreement that the use of weak solutions or solvents give results that more nearly correspond to the results obtained by cropping, yet there is much difference of opinion as to the proper acid or solution to use. This condition, no doubt, is due to the variations in the chemical characteristics of the soils experimented upon.

The present status of the results obtained in this research would seem to indicate that it is very improbable that a marked distinction of any kind can be drawn between "available" and "unavailable" compounds of phosphoric acid in the soil, for the reason that is is not probable that any soil contains a compound or group of compounds which can be wholly removed by plants or dissolved by an acid that is "available," before the remaining compounds are attacked. From the very nature of the changes which are taking place in soils, produced either by crops or natural agencies, there must be more or less change and re-arrangement of the

elements as different ones are attacked, thus making some phosphates available that were previously unavailable, or even the reverse may take place.

It is probable that of the many methods proposed that none of them will be equally well adapted to all classes of soils owing to the selective power of certain acids for different combinations of phosphoric acid, and they will attack different types of soils with more or less vigor, but in the main the *relative* action of all acids on all soils will be alike.

Hall and Plymen have recently made an extensive research and review of the methods proposed for available phosphoric acid, and have reached the conclusion that one per cent. solution of citric acid gave results which are most in accord with the known history of soils. On soils well provided with carbonate of lime, there was little difference in the results obtained with the different acids tried.

With the present state of the perfection of chemical analysis of soils it will still be necessary to put much reliance upon the results obtained by the practical use of the various phosphates in connection with the growing of different crops upon a variety of soils. Upon the following pages will be given brief summaries of prominent experiments of this character.

EXPERIMENTS WITH DIFFERENT FORMS AND SOURCES OF PHOSPHORIC ACID.

Almost as soon as the value of phosphoric acid began to be recognized as an essential plant food, various experiments were conducted as to the value of the phosphoric acid from different materials and sources. These experiments have been repeated from time to time under varying conditions and circumstances. The experiments upon points which seem to have particular value to the farmers in the United States are those conducted at the Pennsylvania Experiment Station and at the Maryland Agricultural Experiment Station. These two series of tests have been performed upon two distinct classes of soils, which are representative of a large percentage of those commonly cultivated, and the conditions under which the tests were carried on are fairly representative of ordinary farm practice. So the results would seem to have much value for practical application.

Article on the determination of available Plant Food, Jour. Chem. Soc., Lond., Jan., 1902, pp. 117-144.

EXPERIMENTS AT THE PENNSYLVANIA STATION, WITH SOLUBLE, REVERTED AND INSOLUBLE PHOSPHORIC ACID.

These experiments had for their object the testing of the value of the different forms of phosphoric acid in actual crop production. as compared with their cost in the market. These experiments were planned by Dr. W. H. Jordan, now director of the New York Agricultural Experiment Station at Geneva. and have been in progress since 1883 or nearly twenty years.

The soil of the plots used in this test is a so-called limestone clay, formed from the decomposition of the surrounding and underlying rock, which is very largely magnesia and limestone. It has the general appearance of a clay loam. Previous to the adoption of this land to the experiments under consideration, it was farmed under the general four or five years' rotation of that section, which includes turning under a good sod every four or five years, and thus the land contained a fair amount of organic matter. The plots were laid out in the spring of 1883. In 1879 and 1881 the land was in grass (clover and timothy) and in 1882 in potatoes. No manure was applied to either crop. The first year the plots were seeded to oats and no fertilizer of any kind was applied, so that some idea could be gained as to the uniformity of the land. In the general work the four year's rotation, common to that part of the State, was adopted, viz: oats, wheat, grass, corn. The fertilizer was applied but twice in the rotation just previous to seeding to wheat and planting to corn.

The last report made upon the results of these tests is contained in the annual report of the Pennsylvania Experiment Station for 1895, and covers the work for twelve years, or three rotations. The kind and amount of fertilizer applied is shown in the following table:

TABLE 9.

Kind and Amount of Fertilizer Applied to the Different Plots.

Plots.	Kind of Fertilizer.	Quantity applied per acre—Lbs.	Quantity of valuable ingredients applied per acre. Nitrogen—Lbs.	Phosphoric acid.	Potash—Lbs.
A & G	Soluble phosphoric acid (dissolved bone black),	200	....	32	....
	Muriate of potash,	200	....	....	100
	Sulphate of ammonia,	240	47	....	....
B & H	Reverted phosphoric acid (dissolved bone black treated with an equal weight of quick lime,	200	....	32	....
	Muriate of potash,	200	....	....	100
	Sulphate of ammonia,	240	47	....	....
C & I	Insoluble phosphoric acid (fine ground bone),	150	4	40	....
	Muriate of potash,	200	....	....	100
	Sulphate of ammonia,	240	47	....	....
D & J	Insoluble phosphoric acid (ground South Carolina rock),	150	....	40	....
	Muriate of potash,	200	....	....	100
	Sulphate of ammonia,	240	47	....	....
E & K	Muriate of potash,	200	....	....	100
	Sulphate of ammonia,	240	47	....	....
F & L	Nothing,	....	....	....	....

The following is a summary of the results as given in that report:

SUMMARY OF YIELD AND VALUE OF CROPS.

WHEAT.

Taking the average for the three years, 1884, 1888 and 1892, insoluble phosphoric acid in the form of ground bone, and the insoluble phosphoric acid in the form of ground South Carolina Rock gave practically identical results, no phosphoric acid, stood third in grain and fifth in straw, reverted phosphoric acid in the form of dissolved bone black treated with an equal weight of lime, fourth in grain and third in straw, and soluble phosphoric acid in the form of dissolved bone black, fifth in grain and fourth in straw.

TABLE 10.

Average Yield Per Acre of Wheat of Plots.

Plot.	Form in Which it Was Applied.	Source of Supply.	Amount applied—Lbs.	Average. Grain. Lbs.	Average. Grain. Bushels. (60 lbs.)	Average. Straw—Lbs.	Average. Total—Lbs.
A & G	Soluble phosphoric acid, ...	Dissolved bone black, ..	200	1,694	28.23	3,014	4,708
B & H	Reverted phosphoric acid, ..	Dissolved bone black,* .	200	1,794	29.90	3 2 8	5,002
C & I	Insoluble phosphoric acid, ..	Ground bone, ...	150	1,895	31.58	3.339	5.234
D & J	Insoluble phosphoric acid, ..	South Carolina rock, ...	150	1,894	31.56	3.338	5.232
E & K	No phosphoric acid, ...	....	......	1,834	30.57	2,798	4,632
F & L	Nothing, ...	....	......	1,351	22.52	1,966	3,317

*Treated with an equal weight of quick lime twelve hours before application.

Assuming the yield of the plots receiving no fertilizer to be 100, the average yield of the different plots is as follows:

Plot.	Form in Which it Was Applied.	Source of Supply.	Amount applied—Lbs.	Average. Grain—Lbs.	Average. Straw—Lbs.	Average. Total—Lbs.
A & G	Soluble phosphoric acid, ...	Dissolved bone black, ...	200	125	153	130
B & H	Reverted phosphoric acid, ..	Dissolved bone black Dissolved bone black and lime,	200	133	163	138
C & I	Insoluble phosphoric acid, ..	Ground bone, ...	150	140	170	145
D & J	Insoluble phosphoric acid, ..	South Carolina rock, ...	150	140	170	145
E & K	No phosphoric acid, ...	....	......	136	143	137
F & L	Nothing, ...	....	......	100	100	100

The value of the crop per acre for the different fertilizers applied is shown in the following table:

TABLE 11.

Plots.	Form of Phosphoric Acid Applied in Connection with Nitrogen and Potash.	Source of supply.	Value of grain.	Value of straw.	Total value.
C & J	Insoluble phosphoric acid,	Ground bone,	$27 79	$6 68	$34 47
D & J	Insoluble phosphoric acid,	South Carolina rock,	27 77	6 68	34 45
B & H	Reverted phosphoric acid,	Bone black and lime,	26 32	6 42	32 74
E & K	No phosphoric acid,		26 90	5 60	32 50
A & G	Soluble phosphoric acid,	Bone black,	24 84	6 03	30 87
F & L	Nothing,		19 82	3 93	23 75

HAY.

Taking the average for the three years, 1885, 1889 and 1893, insoluble phosphoric acid (ground bone) was first, reverted second, soluble third and insoluble (South Carolina rock) fourth.

TABLE 12.

Average Yield of Grass (Hay) per Acre.

Plot.	Form of Phosphoric Acid Applied.	Total yield.	Average for Three Years.	
			Yield.	Proportionate yield.
A & G	Soluble phosphoric acid,	9,500	3,167	155
B & H	Reverted phosphoric acid,	9,900	3,300	161
C & I	Insoluble phosphoric acid,	10,095	3,365	164
D & J	Insoluble phosphoric acid,	9,400	3,133	153
E & K	No phosphoric acid,	7,475	2,492	122
F & L	Nothing,	6,145	2,048	100

The value of the crop per acre for the different fertilizers applied is shown in the following table:

TABLE 13.

Average Yearly Value of Hay per Acre.

Plots.	Form of Phosphoric Acid Applied in Connection with Nitrogen and Potash.	Form in which the Phosphoric Acid Was Applied.	Value.
C & I	Insoluble phosphoric acid,	Ground bone,	$18 69
B & H	Reverted phosphoric acid,	Bone black and lime,	18 33
A & G	Soluble phosphoric acid,	Bone black,	17 59
D & J	Insoluble phosphoric acid,	South Carolina rock,	17 41
E & K	No phosphoric acid,		13 84
F & L	Nothing,		18 38

CORN.

Taking the average for the three years, 1886, 1890 and 1894, insoluble phosphoric acid (ground bone), was first in the yield of grain and stover, reverted second in grain and third in stover, soluble third in grain and second in stover, and insoluble (South Carolina rock) fourth in grain and stover.

TABLE 14.

Average Yield of Corn Plots.

Plots.	Form of Phosphoric Acid Applied.	Average. Ears. Lbs.	Average. Ears. Bushels 70 lbs.	Average. Stover.	Average. Total—Ears and stover.	Average. Proportionate. Ears.	Average. Proportionate. Stover.
A & G	Soluble phosphoric acid,	3,420	48.86	1,942	5,362	148	189
B & H	Reverted phosphoric acid,	3,472	49.60	1,937	5,409	150	189
C & I	Insoluble phosphoric acid,	3,637	51.96	2,073	5,710	157	202
D & J	Insoluble phosphoric acid,	3,335	47.64	1,908	5,243	144	186
E & K	No phosphoric acid,	2,848	40.68	1,667	4,515	123	162
F & L	Nothing,	2,315	33.07	1,027	3,342	100	100

The value of the crop per acre for the different fertilizers applied, is shown in the following table

TABLE 15.

Average Yearly Value of Corn Per Acre.

Plots.	Form of Phosphoric Acid Applied in Connection with Nitrogen and Potash.	Form in which the Phosphoric Acid was Applied.	Value of ears.	Value of stover.	Total value.
C & I	Insoluble phosphoric acid, ...	Ground bone, ...	$27 54	$5 19	$32 73
B & H	Reverted phosphoric acid, ...	Bone black and lime, ..	26 29	4 84	31 13
A & G	Soluble phosphoric acid, ...	Bone black, ...	25 89	4 86	30 75
D & J	Insoluble phosphoric acid, ...	South Carolina rock, ...	25 25	4 78	30 02
E & K	No phosphoric acid, ...	....	21 56	4 17	25 73
F & L	Nothing, ...	....	17 52	2 57	20 09

OATS.

Taking the average for the three years, 1887, 1891 and 1895, insoluble phosphoric acid (ground bone) was first in the yield of grain and straw and weight per bushel, insoluble (South Carolina rock) second in grain and straw and fourth in weight per bushel, reverted third in grain, fourth in grain and fifth in straw and weight per bushel, soluble fifth in grain and third in straw and weight per bushel.

TABLE 16.

Average Yield Per Acre of Oats.

Plot.	Form of Phosphoric Acid Applied.	Average. Grain. Lbs.	Average. Grain. Bus.—(32 lbs.)	Average. Straw—Lbs.	Average. Total grain and straw—Lbs.	Average. Weight per bushel. Lbs.	Average for three years. Grain—Bus. (32 lbs.).	Average for three years. Straw—Lbs.	Average for three years. Total—Lbs.	Average for three years. Weight per bushel—Lbs.
A & G	Soluble phosphoric acid, ...	1,400	43.75	1,337	2,737	39	113	122	117	105
B & H	Reverted phosphoric acid, ...	1,507	47.10	1,326	2,833	39	121	121	121	106
C & I	Insoluble phosphoric acid, ...	1,580	49.39	1,595	3,175	39	127	146	136	106
D & J	Insoluble phosphoric acid, ...	1,541	48.24	1,557	3,101	38	124	142	133	104
E & K	No phosphoric acid, ...	1,457	45.54	1,217	2,674	38	117	111	114	104
F & L	Nothing, ...	1,242	38.81	1,095	2,337	37	100	100	100	100

The value of the crop per acre and weight per bushel for the different fertilizers applied, are shown in the following table

TABLE 17.

Average Yearly Value of Oats Per Acre.

Plots.	Form of Phosphoric Acid Applied in Connection with Nitrogen and Potash.	Form in which the Phosphoric Acid Was Applied.	Value of grain.	Value of straw.	Total value.	Weight per bush—Lbs.
C & I	Insoluble phosphoric acid, ...	Ground bone, ...	$18 27	$3 19	$21 46	39 54
D & J	Insoluble phosphoric acid, ...	South Carolina rock,	17 85	3 12	20 97	38 66
B & H	Reverted phosphoric acid, ...	Bone black and lime,	17 42	2 65	20 07	39 47
E & K	No phosphoric acid, ...	....	16 85	2 43	19 28	38 66
A & G	Soluble phosphoric acid, ...	Bone black, ...	16 19	2 67	18 86	39 00
F & L	Nothing, ...	....	14 36	2 19	16 55	37 16

The conclusions, as set forth in the discussion of the above results, in the report, are as follows:

CONCLUSIONS FROM THE PENNSYLVANIA STATION EXPERIMENTS.

1. That soluble phosphoric acid is too expensive to be used by farmers having a limestone soil similar to the one on which this experiment was made, since fully as good results can be secured by the use of the much cheaper insoluble form.

2. That insoluble phosphoric acid in the form of ground bone is slightly superior to that in the form of South Carolina rock.

3. That corn is benefited more by the application of phosphoric acid than wheat, oats or grass (2-3 clover, 1-3 timothy).

EXPERIMENTS AT THE MARYLAND STATION.

These experiments were planned on a more extensive scale than those in Pennsylvania and were conducted with special reference to the making a study of the availability of the different sources of insoluble phosphates. The detailed report upon these experiments was made in Bulletin No. 68, of the Maryland Agricultural Experiment Station, published in September, 1900. The following gives a summary as to the plan of the experiments and results:

PLAN OF THE EXPERIMENTS CONDUCTED.

The general plan of the experiments conducted in the testing of the availability of different forms of phosphoric acid and means for rendering insoluble phosphates available in the soil. The idea in mind was to make these tests much more than a soil test of this

particular farm, but they were so planned and conducted as to make the results applicable to most parts of this State, and of general interest to agriculture wherever commercial fertilizers are used.

The general idea that pervaded the plan was to imitate nature and get the land as nearly as possible in the same condition it was when a virgin soil and then continue to use nature's methods for maintaining fertility.

It is well known from chemical analysis of soils that they contain sufficient phosphoric acid to furnish all that is needed for good crops for many years. It has also been shown that some soils which fail to produce satisfactory crops contain more phosphoric acid than those that are considered fertile. Now, this difference in fertility must be due to a condition of availability.

An examination of the conditions which prevailed in virgin soils, or in any soil that has just been cleared of its forest growth, soon makes prominent the fact that nature has filled that soil with organic matter; this organic matter not only gives the soil a dark color and fine physical appearance, but it also performs functions in producing chemical changes that cannot take place in that same soil were it destitute of organic matter. Again, we find that a virgin soil will produce satisfactory crops for a number of years without the intervention of commercial fertilizers, but about as soon as the organic matter has been worked out, the soil fails to produce satisfactory crops and the use of phosphates is resorted to.

Now, the phosphoric acid which these soils contained was not in a form soluble in water, nor was it in the form of reverted or dicalcium phosphates, but it was an insoluble phosphate of lime, magnesia, iron or alumina. Though termed insoluble, yet this phosphoric acid was available to crops, through the chemical changes made possible by the presence of organic matter and the compounds formed through its decomposition. It was the water charged with carbonic, humic and other organic acids, formed by the decomposition of vegetable matter, that was able to dissolve the insoluble phosphates of the virgin soils and place them either directly at the disposal of crops, or from such combinations as could be be utilized thereafter.

As soon as the organic matter of the soil was used up, these favorable conditions no longer obtained, and crops could not avail of the natural properties of the soil even though there was an abundance present. Now, if nature's methods are observed again, it will be noticed that wherever she is producing vegetation she has devised means for depositing some vegetable matter in the soil in about the same proportion as she produces.

Taking all these facts into consideration would it not seem reasonable that, in order to avail properly of the phosphates contained

naturally in the soil, that it would be necessary to imitate nature's methods and fill the soil with organic matter. Then, again, could not the phosphoric acid contained in the mineral phosphates be rendered available in the soil through the agency of organic matter if these phosphates were applied in their natural state, except being pulverized? If these questions be answered in the affirmative, and the farmer can arrive at an economical and satisfactory method of providing the requisite amount of organic matter in the soil, then it will be possible to avail of the phosphates already in the soil, and thus, on some lands, make it unnecessary to purchase phosphoric acid. When recourse to purchase becomes necessary, then a cheaper form of phosphoric acid can be used and do away with paying out so much money for dissolved or acid treated phosphates, which, in the end, is practically a means of accomplishing or arriving at a mechanical condition.

These are the ideas that call for the planning and management of the experiments outlined in the following program:

TABLE 18.

Phosphoric Acid Experiments.

(Plots One-Tenth of an Acre Each.)

Plot number.	Kind of Fertilizer and Treatment.	Quantity* per plot—Lbs.	Quantity per acre—Lbs.
	CRIMSON CLOVER SEEDED IN CORN.		
1	Double super-phosphates (Soluble P_2 O_5),	32	319
2	Dissolved bone black (Soluble P_2 O_5),	73½	735
3	Dissolved South Carolina rock (Soluble P_2 O_5),	100	1,000
4	Double super-phosphates (P_2 O_5),	37	370
5	Nothing,	...	...
6	Iron alumina phosphate (Reverted P_2 O_5),	37	370
7	Bone black (Insoluble P_2 O_5),	51½	514
8	Raw bone meal (Insoluble P_2 O_5),	66¾	667
9	Slag phosphate (Insoluble P_2 O_5),	92	920
10	Nothing,	...	...
11	Ground South Carolina rock (Insoluble P_2 O_5),	53	560
12	Florida soft phosphate (Insoluble P_2 O_5),	56	560
	CORN GROUND LEFT BARE DURING WINTER, NO GREEN CROP TURNED UNDER.		
13	Same as No. 8,	66¾	667
14	Same as No. 9,	92	920
15	Nothing,	...	...
16	Same as No. 11,	53	530
17	Same as No. 12,	56	560
	RYE SEEDED ON CORN GROUND.		
18	Same as No. 8,	66¾	667
19	Same as No. 9,	92	920
20	Nothing,	...	...
21	Same as No. 11,	53	530
22	Same as No. 12,	56	560

*These quantities give each plot the same quantity of phosphoric acid (150 pounds per acre, which was determined by analyzing the materials used).

The piece of land used for these experiments lies north of the Experiment Station buildings and along the fence west of the pike. This land is a moderately stiff clay, naturally quite well drained, though fairly level. The general character of the plots runs quite uniform, in fact more so than most pieces of like area in this formation. This land is of water formation and contains iron and alumina and is very deficient in lime.

The history of the cropping of the land used for this test was, so far as known, as follows: In 1888 there was a poor stand of grass and weeds on this land, which was plowed down and seeded to wheat, which was harvested in 1889; grass 1890-91; corn 1892; fallowed 1893, and in wheat 1894—clover and timothy seeded in wheat and gave a good set.

TABLE 19.

Showing Summary of Yields with Different Forms of Phosphoric Acid.

(In Pounds Per Acre.)

	3 Corn Crops.		Wheat.			Total product—5 Crops.		
	Grain—Lbs.	Fodder—Lbs.	Grain—Lbs.	Straw—Lbs.	Hay—Lbs.	Grain—Lbs.	Fodder—Lbs.	Total—Lbs.
Average of 4 nothing plots (5, 10, 15, 20),	9,203	7,387	1,309	2,601	3,862	10,512	13,850	24,362
Average of 3 soluble phosphoric acid plots (1, 2, 3),	9,095	7,453	2,203	3,815	4,350	11,298	15,618	26,916
Average of 2 reverted phosphoric acid plots (4, 6),	9,590	8,035	1,936	3,360	4,525	11,526	15,920	27,446
Average of 5 insoluble phosphoric acid plots, crimson clover turned under (7, 8, 9, 11, 12),	10,073	7,610	1,864	2,837	4,020	11,937	15,467	27,404
Average of 4 insoluble phosphoric acid plots, crimson clover turned under (8, 9, 11, 12),	10,201	7,620	1,946	3,942	4,025	12,147	15,587	27,734
Average of 4 insoluble phosphoric acid plots, nothing turned under (13, 14, 16, 17),	9,615	8,032	2,025	3,611	3,838	11,640	15,481	27,121
Average of 4 insoluble phosphoric acid plots, rye turned under (18, 19, 21, 22),	8,850	7,315	2,012	3,511	3,900	10,862	14,726	25,588
Average of 12 insoluble phosphoric acid plots (8, 9, 11, 12, 13, 14, 16, 17, 18, 19, 21, 22),	9,555	7,656	1,994	3,688	3,921	11,549	15,265	26,814
Average of 3 bone meal plots (8, 13, 18),	10,029	7,907	2,120	3,903	3,867	12,149	14,677	26,826
Average of 3 slag phosphate plots (9, 14, 19),	9,625	7,647	2,160	4,195	4,217	11,795	16,059	27,854
Average of 3 South Carolina rock plots (11, 16, 21),	9,294	7,593	1,890	3,508	4,217	11,184	15,318	26,502
Average of 3 Florida soft phosphate plots (12, 17, 22),	9,273	7,477	1,800	3,147	4,050	11,073	14,674	25,747

DISCUSSION OF MARYLAND STATION RESULTS.

The matter of drawing conclusions from results obtained from plot experiments is always attended with more or less uncertainty, as soil and weather variations will often bring about what may seem to be contradictions. There are, also, often uncontrollable and unnoticed errors produced by the depredations of birds, mice, insects, etc. While these may be very small in themselves, yet when the error is multiplied to represent yields per acre, it may amount to considerable. In order to obviate some of these difficulties, there has been no report made on the experiments under discussion until they have been through five years, and covered several kinds of crops. Even a longer period than this would be desirable, as it would probably serve to confirm some conclusions and to eliminate some doubtful points. These tests will be continued for some years.

The quantities of phosphoric acid applied in these tests are rather more than was necessary and more than would be found economical in practice, but it was thought best in planning the experiments to have an excess present and so endeavor to make the results more pronounced, than to attempt to run on the basis of greatest profit. It was the principles of phosphoric acid fertilization that were desired to be established rather than the limits of the soil requirements.

Nothing Plots (Nos. 5, 10, 15, 20). An examination of Table 19, page 62, shows that the average total product from the plots receiving no fertilizer was considerably below the average yields of all the plots which were fertilized. With some crops there was little increase in the yield through fertilization, and in a few instances the *nothing* plots made a slightly higher yield than those fertilized. This is notably the case with corn. The unfertilized plots of corn made a better average yield than those receiving the soluble phosphoric acid with rye turned under. The failure of the phosphoric acid plots to outyield the *nothing* plots was probably due, in a measure, to the phosphate being very available to the plant, over-stimulated it in the start, and this produced in the plant a condition which made it not so able to withstand the period of drought later in the season and at a time when the grain was forming and there was greatest call for food and activity. This is borne out in a measure by a comparison of the detailed yields as given in Table 19, with the rainfall for that period. There is also a probability that the soluble phosphoric acid, when it entered the soil, was precipitated and formed unions which were not available to the crops, but this condition would not likely produce a decrease in the yields. All of the fertilized plots made very decidedly larger yields

of wheat than the *nothing* plots, which would seem to show that the feeding habit of wheat is very different from corn and that it particularly benefitted by the addition of phosphoric acid.

Soluble Phosphoric Acid (Nos 1, 2, 3). The figures in Table 19 show that all the other forms of phosphoric acid gave higher total yields in five years than the soluble phosphoric acid, except on the plots where rye was turned under. The slightly higher total yield in the case of the rye turned under is accounted for in the corn crops, and is probably due to the rye decomposing slowly and causing the soil to dry out easily, have a poor physical condition and thus suffer from drought. Soluble phosphoric acid seems to be particularly beneficial to wheat where it gave the highest average yield. The probable failure of soluble phosphoric acid to give good yields on corn has been discussed under the *nothing* plots.

A comparison of the different sources of soluble phosphoric acid shows the total yield to stand in favor of the most concentrated fertilizer, or in the order of the plot Nos. 1, 2, 3. The wheat yield was in favor of the dissolved bone black, and hay was best on the dissolved South Carolina rock plots. This was probably due to the action of the sulphate of lime in the dissolved goods, liberating and forming available combinations with the potash in the soil.

Reverted Phosphoric Acid (Nos. 4 and 6). Reverted phosphoric acid gave better total yields for the five crops and better average yields in corn and hay, than soluble phosphoric acid, though not quite so large a yield of wheat. This would seem to confirm the popular idea that reverted phosphoric acid has as great an agricultural value as soluble phosphoric acid. A comparison of reverted phosphate of lime and reverted phosphate of iron and alumina show in every instance with every crop to be in favor of the reverted phosphate of iron and alumina.

Insoluble Phosphoric Acid (Nos. 7, 8, 9, 11, 12, 13, 14, 16, 17, 18, 19, 21 and 22). An examination of Table 19 shows the average yield of five insoluble phosphoric acid plots (Nos. 7, 8, 9, 11 and 12) to have produced considerably more grain than either the soluble or reverted forms of phosphoric acid ,but the amount of fodder was slightly in favor of both the latter. The total product (grain plus the fodder) was more on the insoluble than on the soluble phosphoric acid plots, and within forty-two pounds as much as the reverted phosphoric acid. The value of these results is still further advanced when it is considered that the price of the insoluble phosphoric acid was only about one-half as much as that obtained in the soluble and reverted forms. The above comparisons include only Plots 1 to 12, as these were treated uniformly with respect to turning under crimson clover, green.

A comparison of the different sources of insoluble phosphoric acid as given by the figures in Table 19, page 62, shows slag phosphate to have produced the larger total yield (also a larger yield of both grain and fodder) than either soluble or reverted phosphoric acid. Bone meal produced a little more grain than any other form of insoluble phosphoric acid, but the cost per pound of plant food was about 50 per cent. more than that in the slag and three times as much as that in the South Carolina rock and Florida phosphates. The insoluble phosphate of lime, as furnished by the South Carolina rock, gave better results than the insoluble phosphate of iron and alumina as furnished by the Florida soft phosphate.

GREEN CROPS FOR TURNING UNDER WITH INSOLUBLE PHOSPHATES.

In order to test the value of green crops, or vegetable matter, for rendering insoluble phosphates available, four plots had crimson clover seeded in corn for turning under; four plots had rye in the same manner, while four others had no green crop turned under and were allowed to remain bare during the winter. These plots showed the average results to be considerably in favor of the crimson clover for this purpose. Part of the advantage of the clover no doubt existed in the nitrogen which it furnished and also in the available plant food which it brought from the sub-soil. The clover decomposes rapidly and aids the physical condition of the soil. The rye used seems to have been a disadvantage and did not give as good yields as when no green crop was used. This was particularly the case with the corn crop. The disadvantage rested, probably, in the rye decomposing slowly and thus producing a bad physical state at times and making the corn crop suffer from dry weather.

There is one fact worthy of note, though not directly concerning the experiment under discussion, and that is that by turning under a large amount of leguminous crop like crimson clover, corn can be successfully grown for a number of years in succession with increasing yields.

CONCLUSIONS FROM THE MARYLAND STATION EXPERIMENTS.

In the matter of drawing conclusions it is always well to be cautious and to err, if at all, on the side of conservatism. This policy is particularly well adapted with reference to the application of the results which have been obtained in the experiments under consideration and in using the conclusions that may be drawn.

There is no doubt that the results, as shown by the total product of the crops for five years (last column, Table 19, page 62), are, at

variance with the principles commonly taught and practice generally followed in the matter of fertilization. With these considerations it would be well for those persons who desire to apply these results or use any different source or form of phosphoric acid from that which has been successfully and satisfactorily used in the past, to do so on a limited scale in order to be satisfied that these results will hold under the new and different conditions which may surround each particular case.

The average total results, as given by the figures in Table 19, page 62, show that insoluble phosphoric acid, that is phosphates which have not been treated or dissolved in sulphuric acid (oil of vitriol), have more pounds of crop, both straw and marketable grain, than the phosphoric acid in the soluble and reverted forms; that is, in phosphates which have been dissolved in sulphuric acid. Not only has the yield produced by the insoluble phosphoric acid been greater than that produced by the soluble phosphoric acid, but the cost has been only about one-half as much.

The results obtained show that crops are able to use the insoluble phosphoric of South Carolina rock, notwithstanding the preaching and contention of most fertilizing manufacturers.

The results show that slag phosphate (which is mostly a tetraphosphate of lime, classed by some as available to crops, yet classed by the American Official Methods of Analysis as mostly insoluble phosphoric acid), gives a greater total yield than any of the other insoluble phosphates. The yield of corn (grain), though not quite as much with slag phosphate as with bone meal, yet was greater with wheat and grass. All yields were produced at a less cost with slag phosphates than with bone meal.

Bone meal was the best form of insoluble phosphate for corn, but its accumulative and supposed lasting effects did not show on the wheat and grass. Bone meal has also had an advantage over the other phosphates in furnishing some nitrogen.

The results obtained show crimson clover to be the best crop to use for obtaining organic matter in the soil in order to procure the best results with the insoluble phosphates.

SUMMARY OF PRINCIPAL RESULTS OBTAINED FROM THE MARYLAND STATION EXPERIMENTS.

1. All forms of phosphoric acid produced an increase of crop.

2. The average total yield of the crops fertilized with insoluble phosphoric acid was greater than those with the soluble and reverted forms of phosphoric acid.

3. Reverted phosphoric acid gave a greater total yield than soluble phosphoric acid.

4. Reverted phosphate of iron and alumina gave a higher yield than reverted phosphate of lime.

5. Soluble phosphoric acid gave slightly higher yields of wheat (grain) than phosphoric acid in any other form.

6. Concentrated sources of soluble phosphoric acid gave better results than the low grade sources.

7. Untreated South Carolina rock gave a higher total yield than dissolved South Carolina rock.

8. Slag phosphate produced a greater total yield and at less cost than the average of the soluble phosphoric plots and the bone meal plots.

9. Insoluble phosphoric acid from slag, produced a greater yield than the insoluble phosphoric acid from South Carolina rock and Florida soft phosphate, but at greater cost than the two latter.

10. For the best results with insoluble phosphates, it is desirable to have the land well filled with organic matter. Of the methods tested, crimson clover was the best means of obtaining this.

EXPERIMENTS OF THE OHIO STATION.

Tests have been conducted by the Ohio Agricultural Experiment Station upon the value of different sources of phosphoric acid, at three points in the State, viz: at Wooster, Strongsville and Columbus. The materials used in this test were raw bone meal, dissolved bone black, acid phosphate and basic slag phosphate.

The materials were applied so as to give each plot of ground the same number of pounds of phosphoric acid. The plots also received applications of nitrogen and potash. The quantities were the same for each plot.

The crops used in the test were corn, oats, wheat and hay, grown in a five and three-year rotation.

The results, as obtained so far, are summarized in Bulletin No. 110, pages 65-67, of the Ohio Experiment Station. The following are the summary tables:

TABLE 20.

Value of Average Increase From Different Sources of Phosphoric Acid.

Crops.	Culture.	Number of crops grown.	Carriers of Phosphoric Acid.							
			Acid phosphate.		Raw bone meal.		Dissolved bone black.		Basic slag.	
			Average value of increase.	Rank.	Average value of increase.	Rank.	Average value of increase.	Rank.	Average value of increase.	Rank.
Corn,	5-year rotations,	9	$3 23	3	$2 30	4	$3 35	2	$3 36	1
Oats,	5-year rotations,	10	3 77	2	3 71	3	4 37	1	3 71	3
Wheat,	Both rotations,	17	8 24	4	8 71	2	8 68	3	9 37	1
Hay,	Both rotations,	17	1 29	4	1 91	3	1 92	2	2 70	1

By consolidating the values given in the above table and regarding it as representing the probable outcome of an average rotation in which the four crops have followed each other as in the actual rotation, then the value of the total increase per acre due to the various sources of phosphoric acid, when supplemented with uniform amounts of nitrogen and potash, will be represented by the following figures:

	Per Acre.
Value of increase from basic slag,	$19 14
Value of increase from dissolved bone black,	18 32
Value of increase from raw bone meal,	16 63
Value of increase from acid phosphate,	16 53

Taking basic slag phosphate as 100, we find the following as the proportionate values of these materials as sources of phosphoric acid:

Basic slag phosphate,	100
Dissolved bone black,	96
Raw bone meal,	87
Acid phosphate,	87

While these results are very close together in some cases, and more work will be necessary to determine their relative value, yet there seems to be no doubt that most crops have ability to utilize phosphoric acid that is insoluble in water to a larger extent than is commonly recognized.

TEST MADE BY THE MAINE EXPERIMENT STATION.

The Maine Experiment Station has studied the availability of different sources of phosphates from two standpoints. 1st. The relative producing capacity of different forms of phosphoric acid in growing the crops commonly used in the rotation in use in that section, and 2d. Testing the relative ability of different classes of crops to use different kinds of phosphates.

The experiments conducted under the first head have had the results reported from 1886 to 1891. Since that time no results have been given in any of the Station publications. The summary of the results of the test are given in the Station Annual Report for 1891, page 129, from which the following table is copied:

TABLE 21.

Yield per Acre of Plots Fertilized with Different Forms of Phosphoric Acid, Together With Those of Plots Receiving no Phosphate.

	No manure.	Dissolved bone black 400 lbs., muriate of potash 100 lbs. and sulphate of ammonia 200 lbs. in 1886, 1887 and 1889.	Fine ground bone 300 lbs., muriate of potash 100 lbs. and sulphate of ammonia 140 lbs. per acre in 1886, 1887 and 1889.	Fine ground South Carolina rock 300 lbs., muriate of potash 100 lbs., sulphate of ammonia 200 lbs. per acre in 1886, 1887 and 1889.	Muriate of potash 100 lbs. and sulphate of ammonia 200 lbs. per acre in 1886, 1887 and 1889.	Stable manure 40,000 lbs. per acre in 1886, 1887 and 1889.
	Yield per acre—Bu.	Yield per acre—Bu.	Yield per acre—Bu.	Yield per acre—Bu.	Yield per acre—Bu.	Yield per acre—Bu.
Oats, 1886,	55.7	82.9	76.2	72.2	64.5	73.9
Oats, 1887,	26.7	38.7	31.9	35.5	35.1	34.7
Hay 1888, lbs.,	2,566	2,434	2,800	2,566	2,234	4,010
Fallow, 1889,	......	......	......	......	......	......
Peas, 1890,	12.3	15.0	15.7	14.3	12.7	22.7
Oats, 1891,	38.9	44.9	45.9	38.7	43.2	51.4
Total crop in 6 years:						
Oats,	121.3	166.5	154.0	146.4	142.8	160.0
Hay, lbs.,	2,566	2,434	2,800	2,566	2,234	4,010
Peas,	12.3	15.0	15.7	14.3	12.7	22.7

From this table it will be seen that the dissolved bone black gave the largest total yield of oats, the second largest yield of peas and the smallest yield of hay. Fine ground bone gave the largest yield of hay and peas and stood second in the yield of oats. The ground South Carolina rock stood second in hay and third in oats and peas.

It would appear from the yield of the stable manure plot that the land used was deficient in organic matter, which would account for

the falling off in the yield of the commercial manures and their lack of organic matter would probable be accountable for the insoluble phosphoric acid of the South Carolina rock falling behind. At least, the experiments reported on previous pages by other stations would indicate this fact.

EXPERIMENTS BY THE MASSACHUSETTS STATION.

The Massachusetts Experiment Station has conducted two classes of experiments with different forms and sources of phosphates. In the first test the phosphates were applied on the basis of equal money value and in the second test so as to have the same number of pounds of actual phosphoric acid per acre.

The first series of experiments were commenced in 1890 on a soil which was well exhausted of available fertility. Previous to 1887 the land had been in meadow for a number of years. This meadow was well worn out and yielded but little. From 1887 to 1890 the land was cropped in corn, Hungarian grass, cow peas, vetch and serradella, receiving no manure or fertilizer of any kind. The soil was a fair sandy loam. The following table gives the quality and analysis of the phosphates used:

TABLE 22.

Showing Schedule of Fertilizers Used in the Experiments Conducted by the Massachusetts Station.

Plot number.	Kind of Phosphate.	Per cent. total phosphoric acid.	Quantity per acre.*
†0	No phosphate,		
1	Slag phosphate,	19.0	889
2	Mona Island guano,	21.9	896
3	Florida soft phosphate,	21.7	903
4	South Carolina phosphate,	27.6	917
4	Dissolved bone black,	15.8	546

*The quantity varied from year to year with the market value.
†The no-phosphate plot was not used at the beginning of the experiment, but added in 1895.

In addition to the phosphates each plot received an application of about 300 pounds of nitrate of soda, 400 pounds potash magnesia sulphate per acre. These quantities were continued until 1893 and since that time have been made very much larger though uniform for all the plots.

The applications of phosphates were continued annually until 1893 and since that time none have been used. The object of withholding phosphate was to test their lasting effects. Subtracting the amount of phosphoric acid removed by the crops harvested from that applied, there should have remained in the soil at the end of 1901, about the following quantities of phosphoric acid per acre:

TABLE 23.

Showing Quantity of Phosphoric Acid Remaining in the Soil at the End of Ten Years Cropping.

Plot number.	Kind of Phosphate.	Pounds per acre.
1	Slag phosphate,	375
2	Mona Island guano,	208
3	Florida phosphate,	927
4	South Carolina phosphate,	714
5	Dissolved bone black,	66

The crops which have been raised on the plots in the order of their succession are potatoes, wheat, serradella, corn, barley, rye, soja beans, Swedish turnips,* corn, oats and cabbage.

Representing the yield of the plat giving the highest return by 100, the relative efficiency of the phosphates at the beginning of 1902 stood as follows:

	Per cent.
Slag phosphates,	100.0
Ground South Carolina rock,	92.3
Dissolved bone black,	90.7
Mona Island guano,	88.3
Florida phosphate,	71.5

In 1898 these plots were all limed at the rate of one ton per acre of quick lime. The slag phosphates which contains considerable lime

*Swedish turnips were a failure on account of disease and the results of this crop were not used in computing the relative yields.

had a relatively higher efficiency than the other phosphate before the application of the lime in 1898.

Prof. H. P. Brooks in discussing the results obtained in these experiments remarks as follows: "Attention is called to the fact that the crops on these plots in recent years have not been satisfactory in amount even in the best plots. The fact that no phosphoric acid in any form has been applied during the last nine years sufficiently accounts for this relatively small yield. The results, however, indicate a relatively high degree of availability for the phosphoric acid contained in South Carolina rock and in phosphate slag. There can be no doubt that profitable crops of most kinds can be produced by the liberal use of these natural phosphates; and in a long series of years there would be a considerable money-saving in depending, at least in part, upon these rather than upon the higher-priced dissolved phosphates."

SECOND SERIES OF MASSACHUSETTS STATION.

In the second set of tests of phosphates the application has been made so as to give each plot the same quantity (96 lbs. per acre), actual phosphoric acid. The plots so far have had annual applications. In addition to the phosphoric acid, each plot has received, yearly, nitrogen at the rate of 52 lbs. per acre and potash at the rate of 152 pounds per acre. This test has been in progress four years and has been cropped as follows: Corn, cabbage, corn and in 1900, two crops harvested, oats, hay and Hungarian grass hay.

The following are the kinds of phosphates used in this test:

Plot No.	Kinds of Phosphate.
1,	No phosphate.
2,	Apatite.
3,	South Carolina rock.
4,	Florida soft phosphate.
5,	Slag phosphate.
6,	Tennessee rock.
7,	No phosphate.
8,	Dissolved bone black.
9,	Raw bone.
10,	Dissolved bone black.
11,	Steamed bone meal.
12,	Dissolved phosphate rock.
13,	No phosphate.

No details of yields for each year have been reported, but the results so far have been stated by Prof. Brooks as follows:

1. The slag phosphate evidently furnishes phosphoric acid in an exceedingly available form, the yield being almost equal to dissolved bone black.

2. Florida soft phosphate is apparently a very inferior material, the phosphoric acid evidently becoming available only with great slowness.

3. Steamed bone meal appears to be inferior in availability to raw bone meal.

TESTING THE RELATIVE ABILITY OF DIFFERENT CROPS TO USE VARIOUS FORMS AND SOURCES OF PHOSPHATES.

This is a subject which has been given considerable attention by the Maine and Cornell Experiment Stations. The study has been conducted both in the field and in pot experiments.

These experiments, which have been made in the pots or boxes with sand and artificial soils, while instructive in showing the relative ability of different plants to use various phosphates, yet they have been conducted under such abnormal conditions that the results obtained can not be applied in regular field practice. Particularly is this true in the use of the insoluble phosphates which have been found to be most available upon soils which contained considerable organic matter.

The first test conducted by the Maine Station was made in the field on the farm of H. L. Leland, at East Sangerville, on a slaty gravel soil. The detailed results of this test are given in the Annual Report of that Station for 1891, page 142. Part of the growing season was very dry, which materially interfered with the yields obtained and no doubt to some extent with the results in general.

The following table shows the crops and phosphates used in the test, with the results obtained:

TABLE 24.

Showing Plants and Fertilizers Used and Results of the Same in Testing the Ability of Plants to use Different Phosphates.

Crop.	500 Lbs. Dissolved Bone Black and 100 Lbs. Nitrate of Soda per Acre.	1,000 Lbs. South Carolina Rock and 100 Lbs. Nitrate of Soda per Acre.	500 lbs., Caribbean Sea Guano and 100 Lbs. Nitrate of Soda per Acre.
Plot 1—Clover,	Fair,	Best at close of season,	Very poor.
Plot 2—Oats,	Total crop, 115 lbs.,	Total crop, 80 lbs.,	Total crop, 75 lbs.
Plot 3—Peas,	Total crop, 105 lbs.,	Total crop, 110 lbs.,	Total crop, 51 lbs.
Plot 4—Turnips,	Total crop, 351 lbs.,	Total crop, 369 lbs.,	Failure.
Plot 5—Wheat,	Total crop, 120 lbs.,	Total crop, 105 lbs.,	Total crop, 65 lbs.
Plot 6—Beans,	Total crop, 63 lbs.,	Total crop, 62 lbs.,	Total crop, 54 lbs.
Plot 7—Potatoes,	228 lbs.,	210 lbs.,	153 lbs.
Plot 8,			
Plot 9—Corn,	Failure,	Failure,	Failure.
Plot 10—Barley,	Total crop, 80 lbs.,	Total crop, 75 lbs.,	Total crop, 64 lbs.
Plot 1d—Clover,	Fair,	Best at close of season,	Very poor.
Plot 2d—Oats,	Total crop, 111 lbs.,	Total crop, 83 lbs.,	Total crop, 70 lbs.
Plot 3d—Peas,	Total crop, 97 lbs.,	Total crop, 103 lbs.,	Total crop, 52 lbs.
Plot 4d—Turnips,	Total crop, 340 lbs.,	361 lbs.,	Failure.
Plot 5d—Wheat,	Total crop, 119 lbs.,	Total crop, 102 lbs.,	Total crop, 61 lbs.
Plot 6d—Beans,	Total crop, 66 lbs.,	Total crop, 72 lbs.,	Total crop, 43 lbs.
Plot 7d—Potatoes,	223 lbs.,	211 lbs.,	146 lbs.
Plot 8d,			
Plot 9d—Corn,	Failure,	Failure,	Failure.
Plot 10d—Barley,	Total crop, 77 lbs.,	Total crop, 78 lbs.,	Total crop, 62 lbs.

An examination of the yields of the different crops shows that the dissolved bone black has given, with the majority of them, the largest return and the Caribbean sea guano the least.

With peas and turnips South Carolina rock seems to have been more effective than dissolved bone black. This point is brought out quite sharply. The fact that turnips respond to manuring, with some crude phosphate, has been noted by other experimenters.

The results obtained in this experiment with South Carolina rock on peas agree very closely with the results obtained from all other experiments made by the Station covering this point.

Box or pot experiments upon this subject have been in progress at the Maine Station for some years. This work was started by Prof. Walter Balantine and continued by him until his death; since that time the work has been continued by Prof. L. H. Merrill. The first report upon the subject was made in the annual report for 1893, and the last reported up to this time is in the report for 1898, page 64. The following description of the plan of the experiment and the results obtained are copied from the Fourteenth Annual Report of the Maine Station, pages 66 to 74:

PHOSPHATES USED IN BOX EXPERIMENTS.

In the experiments here recorded, three forms of phosphates were used.

1. Acid Florida Rock.—This was prepared by treating a Florida phosphatic rock with sulphuric acid, thereby converting a large part of the phosphate into an available form. At the beginning of the first experiment this phosphate had the following composition: 20.60 per cent. total phosphoric acid, of which 16.90 per cent. was available (19.97 per cent. soluble, 1.93 per cent. citrate soluble). In the later work it was found that the composition had changed somewhat, but the amount of available phosphate remained about the same.

2. Crude, finely ground Florida rock (floats), containing 32.88 per cent. total phosphoric acid, none of which was soluble, with only 2.46 per cent. soluble in ammonium citrate. This was obtained from the commercial ground rock by stirring it with water, allowing the coarse particles to subside and then pouring off the turbid water. The "floats" used in this experiment consisted of the sediment deposited from these washings.

3. A phosphate of iron and alumina (Redonda). The first sample used contained 49.77 per cent. phosphoric acid, a large part of which, 42.77 per cent. was soluble in ammonium citrate. The Redonda underwent such rapid changes in the intervals between the experiments that it became necessary to prepare fresh quantities at each successive planting. The analysis given above is fairly representative of all.

Twenty grains of the floats, containing 6.58 grains total phosphoric acid, were used for a single box. The other phosphates used were first analyzed and such quantities used for each box that the total quantity present was in each case the same, 6.58 grams. The actual amount of available phosphoric acid thus supplied to each box by the various phosphates were: By the acid rock, 5.39 grams; by the floats, .49 grams; by the Redonda, 5.67 grams.

DETAILS OF THE EXPERIMENT.

The experiments were conducted in one of the green-houses, the plants being grown in wooden boxes, fourteen inches square and twelve inches deep. When filled to within one and one-half inches of the top, the boxes contained 120 pounds of sand. The sand used was taken from a knoll near the river, at a depth of three or four feet, and was nearly free from organic matter. Traces of phosphoric acid were present, but this was in the insoluble form, and the quantity in each box was the same, its presence is not considered objectionable. The sand was carefully screened before being used, and thoroughly mixed with the phosphates and other plant foods.

In each period twelve boxes were used for each kind of plant. In the first box the acid rock was used; in the second, the un-

treated Florida rock, or "floats;" in the third, the phosphate of iron and alumina, or Redonda; the fourth box received no phosphate. The next four boxes were treated in the same manner and so on to the end. Thus, it will be seen that for each kind of plant there were three boxes which received exactly the same treatment In addition to the phosphates, each box received ten grams sodium nitrate, five grams potassium chloride and five grams magnesium sulphate. In the boxes where the Redonda was used, ten grams calcium sulphate were also added. It was intended to supply all the elements essential to the healthy development of the plants, except that every fourth box receivd no phosphate. All the other conditions were made as uniform as possible in order that the differences in growth might fairly be attributed to the differences in phosphates used.

KINDS OF PLANTS GROWN.

Eighteen species of plants were chosen, representing seven orders: Peas, horse beans, clover and alfalfa (Leguminosae); turnips, rutabagas, cauliflower and kohl rabi (Crusiferae); barley, corn, oats and timothy (Graminae); tomatoes and potatoes (Solanaceae); carrots and parsnips (Umbelliferae); buckwheat (Polygonaceae); sunflowers (Compositae).

It was intended to carry each plant through three periods of growth, but the clover, the common red species (T. pratense), could not be matured in the time required for the other plants, and but two crops were grown. The sunflower and buckwheat did not thrive under the conditions of the experiment, and after a single trial were replaced by carrots and parsnips, which were grown for the two following periods. The seed was carefully selected, that only being used which was well formed and of uniform size. Of the larger plants, four or five were grown to each box. The smaller plants were thinned so that the number to each box was uniform for that plant. Such leaves as ripened before the plants matured were removed, dried and added to the plants when harvested. No attempt was made at the pollination. As very few insects were present during the growth of the plants, the fruiting, as might have been expected, was very irregular. As soon as the plants seemed to have attained their maximum development, they were harvested, dried, weighed and the total amount of dry matter determined for each crop grown. In the diagrams that follow the average production for a single period is shown, the heavy lines representing the relative weights of dry matter, and the last column the weights in grams.

TABLE 25.

Diagram Showing Relative Weights of Dry Matter of Plants Grown With Phosphoric Acid From Different Sources.

Crops.	Phosphate.	Comparative Scale.	Weight—grams.
Peas,	Acid rock,		167
	Floats,		122
	Redonda,		94
	No phosphate,		87
Horse beans,	Acid rock,		269
	Floats,		128
	Redonda,		118
	No phosphate,		86
Clover,	Acid rock,		217
	Floats,		169
	Redonda,		126
	No phosphate,		83
Alfalfa,	Acid rock,		107
	Floats,		97
	Redonda,		87
	No phosphate,		90
Turnips,	Acid rock,		222
	Floats,		202
	Redonda,		187
	No phosphate,		119
Rutabagas,	Acid rock,		152
	Floats,		145
	Redonda,		122
	No phosphate,		64
Cauliflower,	Acid rock,		176
	Floats,		167
	Redonda,		107
	No phosphate,		62
Kohl-rabi,	Acid rock,		232
	Floats,		209
	Redonda,		172
	No phosphate,		130
Barley,	Acid rock,		338
	Floats,		171
	Redonda,		186
	No phosphate,		146
Corn,	Acid rock,		218
	Floats,		85
	Redonda,		98
	No phosphate,		31
Oats,*	Acid rock,		662
	Floats,		307
	Redonda,		380
	No phosphate,		319
Timothy,	Acid rock,		410
	Floats,		329
	Redonda,		346
	No phosphate,		353

TABLE 25—Continued.

Crops.	Phosphate.	Comparative Scale.	Weight—grams.
Tomatoes,	Acid rock,		135
	Floats,		92
	Redonda,		79
	No phosphate,		36
Potatoes,	Acid rock,		260
	Floats,		187
	Redonda,		156
	No phosphate,		151
Carrots,	Acid rock,		214
	Floats,		141
	Redonda,		149
	No phosphate,		135
Parsnips,	Acid rock,		237
	Floats,		151
	Redonda,		155
	No phosphate,		163
Buckwheat,	Acid rock,		107
	Floats,		54
	Redonda,		51
	No phosphate,		37
Sunflowers,	Acid rock,		101
	Floats,		14
	Redonda,		15
	No phosphate,		11
Turnips, roots,	Acid rock,		100
	Floats,		70
	Redonda,		90
	No phosphate,		44
Rutabagas, roots,	Acid rock,		62
	Floats,		47
	Redonda,		32
	No phosphate,		16
Cauliflower, edible portion.	Acid rock,		50
	Floats,		19
	Redonda,		......
	No phosphate,		......
Kohl-rabi, edible portion,	Acid rock,		153
	Floats,		129
	Redonda,		92
	No phosphate,		60
Potatoes, tubers,	Acid rock,		185
	Floats,		131
	Redonda,		140
	No phosphate,		115
Carrots, roots,	Acid rock,		173
	Floats,		109
	Redonda,		113
	No phosphate,		102
Parsnips, roots,	Acid rock,		196
	Floats,		115
	Redonda,		114
	No phosphate,		120

*In the case of the oats and timothy the scale has been reduced one-half to accommodate the lines to the space allowed. The relative length of the lines for the same plant has been maintained.

RESULTS OF THE MAINE STATION EXPERIMENTS.

In every case the acid rock gave the best returns. The gain was especially marked with the family Gramineae, three members of which, the barley, corn and oats, yielded nearly double the amount produced by either the floats or Redonda. The effect upon the sunflowers and buckwheat was especially marked, but if these plants could have been brought to full development it is probable the gain would have been less apparent.

If we compare the amount of dry matter produced by the acid rock with that produced by the floats for all the crops grown, we find the balance in favor of the acid rock to be 52 per cent. In other words, the effect of the available phosphoric acid, as compared with the insoluble phosphate, was to increase the product more than one-half.

In nearly every case the floats gave results second only to those obtained with the acid rock. With this phosphate the Cruciferae gave returns within ten per cent. of those obtained by the acid rock. This is not true of the edible portion of these plants, however, for there the good effects of the acid rock were more marked.

Of the three forms of phosphate used, the Redonda proved the least valuable, though supplying a larger amount of available phosphoric acid than the floats. In most cases, it showed itself inferior even to floats. The Germineae furnished an interesting exception to this rule, yielding results with Redonda above those given by the floats.

The small yield from the boxes in which no phosphate was used is sufficient indication of the extreme poverty of the soil, and confirms the belief that the amount of phosphoric acid thus supplied is not sufficiently large to seriously affect the experiment.

It is interesting to note that the plants of the same family show a remarkable agreement in their behavior towards the various phosphates. The striking manner in which the Gramineae respond to the stimulus of the acid rock has already been alluded to. In no other case is the effect so marked. Another peculiarity of the members of this family is shown in their conduct toward the Redonda. The relative value of this phosphate and floats is here the reverse of that shown by nearly all the other plants. The failure of the Cruciferae to respond to the acid rock furnishes a good illustration of a similar kind. The Umbelliferae, though responding to the acid rock, seem to derive no benefit from either the floats or Rendonda, since neither of the phosphates increase the yield above that obtained where no phosphates were used. This is true both of the whole plant and the roots.

The alfalfa shows a strange indifference to the precise form in which the phosphoric acid is supplied. The crop was light in every case, and the phosphoric acid already present in the barren soil used, seems to have sufficed for the slender product.

STIMULATING EFFECT OF ACID PHOSPHATE IN THE EARLY STAGES OF GROWTH.

A report of this work would be incomplete if it failed to take note of certain facts observed in the course of the experiment which cannot be shown in the diagram, where only the final results are given.

Throughout the whole series of experiments the effect of the acid rock was marked, the plants receiving it in nearly every case at once taking the lead, and keeping it to the end. The horse-beans furnish a marked exception to this rule, the more nearly equal development being perhaps due to the large amount of nutriment stored in the seed. When this supply was exhausted, the phosphoric acid hunger manifested itself.

In by far the larger number of cases, especially with the clover, timothy, turnips and rutabagas, the good effects of the acid rock were more marked during the first few weeks of growth than at a later stage, when the roots become more fully developed, and had begun to forage for themselves. This fact, also, is shown in the figures of the clover and timothy. It would appear that the young plants feed but little upon the insoluble phosphates, but that the organic acids present in the sap of the roots exert a solvent action upon the insoluble phosphates in the soil, gradually converting them into available forms.

It will be noticed that in this work only the immediate effect of the phosphates has been taken into consideration, no mention having been made of the unused phosphoric acid remaining in the soil at the close of the experiment. In actual field work, the good effect of the ground rock would, of course, be far more lasting than that of the acid rock.

Box experiments were made at the New Hampshire Experiment Station in 1893, with winter rye, the phosphoric acid being supplied by roasted Redonda, ground bone and basic slag. The result showed that the rye gave nearly as good returns with the roasted Redonda as with the other phosphates. The result confirms the work here reported. It will be seen by reference to the diagram here given that the corn, barley, oats and timothy (plants closely related to rye) gave better results with the Redonda phosphate than with the finely ground Florida rock.

SUMMARY OF THE MAINE STATION EXPERIMENTS.

1. Plants differ in their ability to feed upon crude phosphates.

2. Turnips, rutabagas, cauliflowers and kohl-rabi gave nearly as good returns with the Florida rock as with the acid rock.

3. In every other case the good effect of the acid rock was very marked.

4. In most cases the crude Florida rock yielded better returns than the Redonda.

5. Barley, corn and oats seem to require an acid (soluble) phosphate.

6. When early maturity is desired, the acid rock can profitably be used.

7. The largely increased production obtained by the use of the acid rock will often determine the success of the crop.

8. The solubility of a phosphate in ammonium citrate is not always the correct measure of its actual value to the plant.

TESTS MADE BY THE CORNELL UNIVERSITY EXPERIMENT STATION.

In the winter of 1900-1901 some experiments were conducted at the Cornell Experiment Station upon the relative ability of various orders of plants to utilize different sources and forms of phosphoric acid. These tests were conducted in a green-house and the plants grown in box pots. The soil in which the plants were grown was a white quartz sand prepared by grinding quartz rock. The soil or medium furnished practically no plant food, so that it was necessary to furnish an artificial supply of the essential plant foods. All conditions were made exactly similar except as to the kind of phosphoric acid supplied. The actual amount of phosphoric acid supplied the different boxes was the same, but the sources were different.

The following table gives the variety of plants used, the source of phosphoric acid supplied and the results obtained:

TABLE 26.

Diagram Showing Relative Weights of Dry Matter of Plants Grown With Phosphoric Acid From Different Sources.

Order.	Crop Grown.	Phosphate Used and Comparative Scale of Product.	Weight in grams of dry matter.
Leguminoseae,	Clover,	Acid phosphate	30.[illegible]
		Bone black	22.[illegible]
		Basic slag	15.7
		Floats	1.45
		No phosphoric acid	2.[illegible]
	Peas,	Acid phosphate	21.78
		Bone black	22.[illegible]
		Basic slag	9.9[illegible]
		Floats	9.76
		No phosphoric acid	11.[illegible]
Cruciferae,	Rape,	Acid phosphate	2[illegible].71
		Bone black	18.[illegible]
		Basic slag	[illegible]
		Floats	23.3[illegible]
		No phosphoric acid	3.71
	Radishes,	Acid phosphate	1[illegible].15
		Bone black	14.1
		Basic slag	12.8
		Floats	7.
		No phosphoric acid	1.7

TABLE 26—Continued.

Order.	Crop Grown.	Phosphate Used and Comparative Scale of Product.	Weight in grams of dry matter.
Gramineae,	Oats,	Acid phosphate	26.91
		Bone black	37.93
		Basic slag	24.46
		Floats	17.71
		No phosphoric acid	13.14
	Barley,	Acid phosphate	18.2
		Bone black	25.77
		Basic slag	21.6
		Floats	3.22
		No phosphoric acid	5.90
Umbelliferae,	Parsnips,	Acid phosphate	24.91
		Bone black	32.18
		Basic slag	5.78
		Floats	.69
		No phosphoric acid	.41

The results obtained by the tests of both the Maine and Cornell Experiment Stations are valuable in that they show the relative ability of plants of various kinds to feed upon the different forms of phosphoric acid. These results also show that upon soils which are deficient in organic matter it is decidedly best with most crops to use some phosphate furnishing soluble phosphoric acid. Nevertheless, these results seem to point out that the insoluble phosphates might be used on quite barren soils to grow such crops as turnips or rape for soil renovation or green manure purposes.

Again, these results, when considered in connection with the results of field experiments made upon soil which contained a fair amount of organic or vegetable matter, would seem to give additional evidence as to the necessity of having lands full of organic matter in order to obtain good results from applications of insoluble phosphates.

SOME FOREIGN EXPERIMENTS WITH PHOSPHATES.

Numerous experiments have been made from time to time upon different phases of points effecting the availability of phosphates and forms of phosphoric acid. To give an abstract from all of these tests would not be possible in a work of this kind, yet it might be interesting to note briefly a few which have been repeated recently and which would seem to be closely related to the tests made in this country.

Experiments on the relative value of different phosphates, by Dimitry Prianischnihoff (Vol. 56 (1901), pp. 107-146, Landw. Versuchs-Stationen).

This was also a test of the relative ability of various crops to use sparingly soluble phosphates. The tests were made by pot culture in sand. The following numbers indicate the relative amounts of phosphoric acid assimilated as shown by the results up to the time of making the report:

	Phosphorite.	Bone meal.	Basic slag.	Ca HPO_4.
Cereals,	0-10	40	60-70	100
Buckwheat, lupens, etc.,	60	90	100	100

The summary makes the following statements:

Phosphorite should not be applied to light soils (probably not to any soil long cultivated) for cereals, but only for buckwheat, mustard, lupens and peas. In the case of peat or muck land, however, and acid soils generally, phosphorite may be applied for any crop. An experiment on black soil is recorded in which, without manure, buckwheat gave more produce than wheat; the addition of phosphorite and of sodium di-hydrogen phosphate greatly increased the yield of wheat but not of buckwheat. This is attributed to the ability of buckwheat to make use of sparingly soluble phosphoric acid. Experiments are also described upon the use of various ammonium salts in conjunction with the phosphates, and the results showed that they acted as solvents and made the phosphoric acid available.

THE USE OF PHOSPORITE AND GREEN MANURING.

Some experiments on this subject were conducted by A. N. Engelhardt, which are abstracted in Chem. Centralblat, 1901, p. 232. The following were the results obtained from three year's field experiments: The fine-ground untreated phosphate was especially effective on cereals. The effects was best on soils containing an abundance of organic matter. The finer the meal and the greater the percentage of phosphate of lime the more effective was the phosphate. The best results were obtained with rye, but the following crop of oats was also benefited. When the phosphorite was applied to rye, oats or flax, and these crops followed by a crop of rye, to which barnyard manure was applied, the yield of the latter was much better than of rye which had received only an application of barnyard manure.

The results showed that ground phosphorite can be profitably used to supply phosphoric acid on soils which contain a sufficient amount of nitrogen, potash and lime. When its action lessens, green manuring should be resorted to. Lime and marl used in conjunction with the phosphorite was advantageous.

CONCLUSION.

In conclusion, it may be said that there are many more experiments that might be referred to which have covered the same points already considered, and many others which have had to do with particular phosphates, but that it is needless to go over them in detail as the results are, in most instances, practically the same as those already cited and are simply confirmatory of the statements which have been made from time to time in this article.

The experiments which have been quoted from show that many of the popular notions regarding phosphates are not fully warranted

and that much of our daily practice is either based upon pre-conceived ideas or been moulded by such information as has been given out which would serve the interest of fertilizer manufacturers. It is certain that a careful study of the results of the experiments given in the preceding pages will make it evident to all that there is more need of a careful study of the character of land to which the phosphate is to be applied and then to use the form of phosphoric acid and other accessory measures which will gain the desired results most economically.

REVIEW OF THE RESULTS OF THE EXPERIMENTS.

All of the experiments which have been conducted upon the use of phosphoric acid in agriculture have given results which seem to warrant the general statement that much of the practice now followed in the use of phosphates is not founded upon facts; but are probably backed either by the tradition and statements gathered from the customs of our forefathers or promulgated by the teachings of the commercial world. The latter, in many cases, are much colored for the sake of self preservation and financial gain.

There is no doubt but that the first step in the economical use of phosphates is to imitate nature and endeavor to keep the soil well supplied with organic matter; for it is only by such means that the phosphates contained in the soil naturally and those applied artificially can be fully utilized by the cultivated crops.

It is very evident from all the tests cited that some crops, particularly the turnip family, have a greater ability than others to use crude or insoluble phosphates and these experiments would certainly teach that the aim should be to employ such crops for rendering insoluble phosphates available and by such a practice save much that is now being spent for sulphuric acid and the cost of manufacturing the soluble phosphates.

The experiments, in most instances, show that the presence of carbonate of lime is of considerable advantage in increasing the availability of phosphates.

Some of the tests show that the iron and alumina phosphates are much more valuable as plant foods than is generally considered, in fact under some circumstances they seem to be as soluble and even superior to lime phosphates.

In regard to the so-called available phosphoric acid of commercial fertilizers, the results all point to the fact that there is no difference in it depending upon its source; that is, a pound of available phos-

phoric acid from a mineral source is just as valuable as a pound from an organic source. With this fact confronting us there seems to be nothing to warrant the purchase of a dissolved bone instead of a dissolved rock, unless the phosphoric acid in the bone costs no more than that in the rock. In other words, a farmer can not afford to pay more per pound for available phosphoric acid in dissolved bone than he can for that in dissolved rock any more than he would pay more for sugar from cane than he would for sugar from beets. In either case the only justification that could be given would be that there was no departure from the traditions of his grandfathers.

The results of both field and plot experiments show that certain classes of phosphates are more available and hence have a higher agricultural value than would be given them by official methods of analysis. This condition would seem to warrant some modified method for analyzing such materials. This is particularly true of the tetra-phosphates when used on some soils.

The best advice and general rule which can be given in the matter of the intelligent use of phosphates is, to study the special conditions that surround the particular case in hand, observe the methods of nature and compare these circumstances with those of the experiments given, then apply the results with such modification as good common sense would seem necessary to meet the demands of local conditions.

APPENDIX.

APPENDIX.

LIST OF PUBLICATIONS OF THE PENNSYLVANIA DEPARTMENT OF AGRICULTURE.

ANNUAL REPORTS.

*Report of the State Board of Agriculture, 336 pages, 1877.
*Report of the State Board of Agriculture, 625 pages, 1878.
*Report of the State Board of Agriculture, 560 pages, 1879.
*Report of the State Board of Agriculture, 557 pages, 1880.
*Report of the State Board of Agriculture, 646 pages, 1881.
*Report of the State Board of Agriculture, 645 pages, 1882.
*Report of the State Board of Agriculture, 645 pages, 1883.
*Report of the State Board of Agriculture, 648 pages, 1884.
*Report of the State Board of Agriculture, 645 pages, 1885.
*Report of the State Board of Agriculture, 646 pages, 1886.
*Report of the State Board of Agriculture, 650 pages, 1887.
*Report of the State Board of Agriculture, 648 pages, 1888.
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FERTILIZER VALUATIONS—1902.

The object of an official valuation of commercial fertilizers is to enable the consumer to judge approximately whether he has been asked to pay for a given brand more than the fertilizing ingredients it contains and market conditions prevailing at the time would warrant. It is clear, therefore, that no attempt is made in this valuation to indicate whether the fertilizer valued possesses a greater or less crop-producing capacity than another fertilizer; but only whether it is higher priced than another of the same general composition. For this purpose it must be so computed as to include all the elements entering into the cost of a fertilizer as it is delivered to the consumer. These elements may be conveniently grouped as follows:

1. The wholesale cost of the ingredients.

2. The jobbers' gross profit on the sale of the ingredients; this includes office expenses, advertising, losses, etc.; for the purpose of the present computation it may be assumed that the sum of this gross profit and the wholesale cost of the ingredients, is equivalent to the retail price of the single ingredients near the wholesale markets in ton lots of original packages for cash.

3. The expense and profit of mixing: This item applies only to complete fertilizers, rock and potash, and ammoniated rock; not to dissolved or ground bone, or to dissolved rock.

4. The expense and profit of bagging.

5. Agents' commission: This item includes not only the commission proper, but every advance in price due to the sale of the goods through an agent in small quantities on time, rather than directly to the consumer in ton lots for cash.

6. Freight from the wholesale market to the point of delivery.

The valuations for 1901 were based:

1. Upon the wholesale prices from September 1, 1900, to March 1, 1901, of the raw materials used in fertilizer manufacture, the quotations of the New York market being adopted for all materials except acidulated phosphate rock and ground bone.

2. Upon an allowance of 20 per cent. of the wholesale prices, above mentioned, to cover jobbers' profits.

By adding the 20 per cent. allowed for jobbers' gross profit to the wholesale price of the several raw materials, the retail price in original packages at the jobbers' warehouse is obtained.

Since the amount of the several valuable fertilizing constituents in the various raw materials is known, it is a simple matter to determine the corresponding retail value per pound of the valuable fertilizing constituents yielded by each raw material. A schedule of these pound values affords a convenient basis of computation of the value per ton of various fertilizers, whose composition is ascertained by analysis.

The values assigned, for the present, to the other elements in the cost of the fertilizer at the point of delivery are:

3. For mixing, $1.00 per ton.

4. For bagging, $1.00 per ton, in all cases except those in which the article was sold in original package; the cost of the package being, in such cases, included in the wholesale price.

5. For agents' commissions, 20 per cent. of the cost of the goods f. o. b. at the jobbers' or mixers' warehouse.

6. For freight, $2.00 per ton; the cost of the freight in lots of twelve tons or over, from the seaboard to Harrisburg, averaging $1.88 per ton.

The following valuation of dissolved South Carolina rock illustrates the method:

Phosphoric acid.	Per cent.	Weight per ton.	
Soluble,	11.50	230 lbs. at 3c.	$6 90
Reverted,	2.50	50 lbs. at 2½c.	1 25
Insoluble,	1.00	20 lbs. at 1½c.	30
Retail cash value of ingredients,			$8 45
Bagging,			1 00
Cash value of goods ready for shipment,			$9 45
Agents' commission, 20 per cent.,			1 89
Freight,			2 00
Commercial value per ton,			$13 34

It is not to be expected, of course, that the valuations thus computed will precisely represent the fair price to be charged for a brand in each locality and in every transaction. Market conditions, competition, distance from factory, all introduce minor variations. Nevertheless, to make the approximation reasonably close, the average valuation of a given class of goods ought to agree closely with its ascertained average selling price. Whenever such an agreement is no longer obtained by the use of a schedule, it is evident that the schedule of retail values of the constituents, or the added allowances for mixing, etc., requires revision.

It is needful to note here another factor greatly affecting the practical accuracy of these approximations. Their computation would offer little difficulty and their usefulness be far greater, if, by the ordinary methods of analysis, the exact nature of the ingredients used to supply the several fertilizer constituents, were capable of certain determination. This is, however, possible, to-day, to only a limited extent. The valuations are, therefore, based on the assumption that the fertilizers are uniformly compounded from high quality ingredients, such as are commonly employed in the manufacture of fertilizers of the several classes. Consumers should carefully avoid the error of accepting such valuations as infallible; they are not designed to be used for close comparison of single brands, but only to indicate whether the price asked for a fertilizer is abnormal, assuming good quality for the ingredients used. From this it is clear that, except as high freights may require, the selling price of a brand should not far exceed the valuation; but that a fertilizer may be made of inferior materials and yet have a high valuation.

The valuations used during 1900 were modified for use during 1901 in accordance with the changes in wholesale prices of fertilizing ingredients and to make the valuations more closely follow the selling price.

The following comparative statement shows the valuations and selling prices of the several classes of fertilizers during 1900 and 1901.

Fertilizers.	Number of samples.	Valuation.	Selling price.	Difference of valuation from selling price.
Spring, 1900.				
Complete,	276	24.61	25.38	—0.77
Rock-and-potash,	48	14.71	17.25	—2.64
Dissolved bone,	2	30.87	26.00	4.87
Ground bone,	30	25.91	28.42	—2.51
Dissolved rock,	56	13.48	13.57	—0.09
Fall, 1900.				
Complete,	130	24.00	23.22	0.81
Rock-and-potash,	33	14.63	18.11	—3.48
Dissolved bone,	2	22.74	23.50	—0.76
Ground bone,	17	26.87	28.73	—1.86
Dissolved rock,	31	13.11	13.96	—0.85
Spring, 1901.				
Complete,	291	24.76	23.92	0.84
Rock-and-potash,	60	14.60	16.20	—1.60
Dissolved bone,	1	29.00	28.00	1.00
Ground bone,	44	28.71	27.59	1.12
Dissolved rock,	49	13.51	13.90	—0.39
Fall, 1901.				
Complete,	179	23.75	22.28	1.47
Rock-and-potash,	42	14.23	16.09	—1.86
Dissolved bone,	5	23.36	23.91	—0.55
Ground bone,	33	27.69	25.94	1.75
Dissolved rock,	49	13.82	13.18	0.64

The valuations during 1901 for the more important classes of fertilizers were considerably higher than the selling prices; the difference was more marked in the fall than in the spring. As usual, the selling prices of rock-and-potash maintain a disproportionately high level.

The general tendencies of the wholesale market may be judged from the following comparative statement, obtained from the weekly reports of the *Oil, Paint and Drug Reporter*, of New York City, showing the average wholesale prices of fertilizer raw materials from September 1, 1900, to March 1, 1901, and from September 1, 1901, to March 1, 1902.

Wholesale Prices of Fertilizer Ingredients, New York: *Oil, Paint and Drug Reporter.*

Substance.	Amount priced.	Average price Sept., 1900, to March, 1901.	Average price Sept. 1, 1901, to March, 1902.	Prices Sept.-Feb., 1901-2, in per cent. of prices 1900-01.
Sulfate of ammonia,	Cwt.,	2.8005	2,8324	101.1
Nitrate of soda,	Cwt.,	1.8153	1,9889	109.5
Dried blood, H. G.,	Unit (20 lbs.),	2.3127	2.2375	96.7
Concentrated tankage,	Ton,	16.227	1[illegible]25	100.1
Rough bone,	Ton,	20.983	18.25	86.9
Ground bone,	Ton,	21.842	20.50	93.8
Bone meal,	Ton,	19.70	17.72	89.9
Fish guano (dry),	Ton,	23.00	24.50	106.5
Fish guano (acid),	Ton,	12.00	13.25	110.4
Refuse bone-black,	Ton,	19.30	19.00	98.4
Phosphate rock (Charleston),	Ton,	7.25	7.48	103.2
Phosphate rock (Tennessee),	Ton,	3.25	3.328	102.4
Acid phosphate,	Unit (20 lbs.),	.6422	.625	97.3
Double manure salts,	Cwt.,	1.0725	1.13	105.4
Sulfate of potash,	Cwt.,	2.07	2.125	102.6
Kainit,	Ton,	9.30	9.05	97.3
Muriate of potash,	Cwt.,	1.8475	1.8475	100.0
Sulfuric acid, 66 —° B.,	Cwt.,	1.475	1.573	106.6

In ammoniates, such as dried blood or concentrated tankage, the unit is of ammonia, of which 82.35 per cent. is nitrogen; in acid phosphates, the unit is of phosphoric acid (phosphorus pentoxid).

The nitrogenous materials and animal sources of phosphoric acid show the following changes from last year's prices. Sulfate of ammonia has advanced slightly, while in the case of nitrate of soda and fish guano there has been a distinct advance over last year's figures. Concentrated tankage remains practically the same. Dried blood and refuse bone-black have fallen off slightly; rough bone and bone meal show a marked decrease. The following data are from the monthly reports of Thos. J. White & Co., fertilizer brokers, Baltimore, Md., giving wholesale quotations upon ammoniates.

Wholesale Prices of Ammoniates: Reports of Thos. J. White & Co., Baltimore, Md.

	Prices Sept. to March, 1900-1901.	Prices Sept. to March, 1901-1902.
Sulfate of ammonia, per cwt.		
Foreign, f. o. b. Baltimore,	2.76	2.79
Domestic, f. o. b. Boston,	2.76	†2.75
Ground blood, f. o. b. Chicago, per unit ammonia,	2.12	2.015
Concentrated tankage, f. o. b. Chicago, per unit ammonia,	1.96	1.875
Crushed tankage, f. o. b. Chicago, per ton :		
10 per cent. ammonia, 15 per cent. bone phosphate,	*22.63	20.67
10 per cent. ammonia, 10 per cent. bone phosphate,	*20.375	19.49
Crushed tankage, c. a. f. Baltimore, per unit ammonia,	2.29	2.26
Dried fish, f. o. b. factory, per unit ammonia,	‡2.14	§2.175

†f. o. b. Everett; quotations for September only.
*Lacking December quotations.
‡Lacking December and February quotations.
§Quotations for September only.

The foregoing table indicates the following variations from prices a year ago. Sulfate of ammonia has increased 1 per cent. and the other ammoniates have decreased as follows: Ground blood, 5 per cent.; concentrated tankage, 4 per cent.; crushed tankage, 10½ and 15, and 10 and 10, 8½ per cent., and crushed tankage sold per unit of ammonia 1 per cent.

The *Engineering and Mining Journal* of New York City, gives quotations of sulfate of ammonia and nitrate of soda for January, 1902, 2.8375 and 1.97 per cwt., respectively, as compared with 2.76 and 1.85 for the same month last year. All these figures are confirmatory of those already quoted showing a slight advance in the wholesale price of ammonium sulfate, a marked advance in the case of nitrate of soda, a shrinkage in the value of blood and tankage and quite a marked decrease in the case of bone.

Of the animal raw materials furnishing phosphoric acid, refuse bone-black only has fallen off somewhat in price. The following summary from the *Engineering and Mining Journal* shows the prices of rock phosphate. Lower freight rates helped to increase the export trade about 17 per cent., 750,000 tons being shipped as against 619,996 tons in 1900.

Florida Phosphate: The largest business was done in high grade rock, the exports amounting to 428,000 tons or about 80,000 tons more than last year. The chief demand for pebble phosphate was for home consumption, the exports, however, being larger than last year. Prices during the year were: For high grade rock ((77-80) per cent.) f. o. b. Fernandina, $7.25 in January, $6.75 from February to

November inclusive, and $7.25 in December, making the average for the year $6.83 per ton, this being below the price for 1900. During January and February of this year, the price rose, being quoted during that time at $7.50. Land pebbles (68-73 per cent.) were $4.14 in January, $3.93 from February to September inclusive, $3.75 in October and $3.13 in November and December, making the yearly average $3.80. During January and February of this year prices were $3.00 to $3.25.

Peace River phosphate was less active, 18,790 tons being exported as compared with 21,427 tons last year. The average prices f. o. b. Fernandina, were $2.94 in January, $2.63 from February to October, and $2.38 in November and December, the average for the year being $2.61. During January and February of this year quotations were $2.25 to $2.50.

Tennessee Phosphates: The export trade is growing, over 130,000 tons of high grade rock being sent abroad. As a result of competition, prices were lower than in 1900. The f. o. b. prices of export rock were $2.88 in January, $3.25 in February, $3.38 in March to July inclusive, $3.68 in August and September, $3.30 in October, $3.31 in November and $3.50 in December; yearly average, $3.33, and for January and February of this year, $3.50.

Prices on domestic orders for high grade rock (78 per cent.) averaged $2.78 in January and $3.13 in December, or $2.97 per long ton for the year, f. o. b. Mt. Pleasant. During January and February of this year prices were $3.00 to $3.25.

Domestic rock (75 per cent. bone phosphate) averaged $2.63 in January, and $2.88 in December, or $2.75 for the year; and for the 70.72 per cent. grade, $2.13 in May to July, $2.29 in September and $2.25 in December, or $2.21 for the year. The prices for January and February of this year upon these grades were $2.75 to $3.00 and $2.25 to $2.50 respectively; all f. o. b. Mt. Pleasant.

In South Carolina, production was curtailed owing to heavy stocks in the early part of the year and small demand. Coastwise shipments and exports decreased over last year. The average prices f. o. b. Ashley river, for dried rock were $4.50 in January and February, $3.25 in March to July, making $3.65 for the year. Of the crude rock, comparatively little has been sold out of the State, the average price for the year being $3.36. During January and February of this year land rock was quoted at $3.25 and river rock at $2.75 to $3.25.

The mine prices for 1901, at all the principal points of production, were materially lower than during 1900, to a degree which is not fully reflected by the New York quotations.

Raw Materials of Acid Manufacture.

Brimstone: High prices and increased consumption of pyrites by acid-makers have reduced the imports of brimstone about 7,000 tons. The total imports into the United States for 1901, as given by the *Engineering and Mining Journal*, were about 160,000 tons, chiefly in best unmixed seconds; and these were consumed largely by paper mills. Prices were maintained by the trust in Sicily nearly all through the year and would have continued to rise had not the Anglo-Sicilian Co. been compelled to make concessions. As compared with those of 1900, New York prices show an increase of 77 cents a ton for spot and 82 cents for shipments. Best unmixed thirds sold in New York at $2 to $3 below best unmixed seconds. The average New York price for 1901 for best unmixed "seconds" "spot" was $22.95.

Pyrites: The demand has been good and deliveries on contract large at good prices. Domestic production has increased and imports during the year 1901 were 17 per cent. above those for 1900. The U. S. Bureau of Statistics shows imports for the year ending June 30, 1901, of 339,217 tons, valued at $1,166,686, or $3.44 per ton. For the year ending June 30, 1900, the imports were 334,131 tons, at $3.61, in both cases most of the imports being from Spain.

The *Engineering and Mining Journal* estimates the imports into this country for 1901 as 389,000 tons, chiefly from Spain. Low freight rates favored these large imports. The same journal summarizes prices as follows: Spanish pyrites (Huelva, 46-51 per cent. sulfur) were sold at 12 to 14 cents per unit ($5.52 to $7.14 per ton) ex ship Atlantic ports. Domestic pyrites, 42-44 per cent. sulfur, f. o. b. Mineral City, Va., $4.90 per ton for "lump" ore and 10 cents per unit ($4.70 per ton) for fines." Massachusetts, f. o. b. Charlemont, $5.00 to $5.50 for "lump" and $4.75 to $500 for "fines." The raw materials for acid manufacture were, therefore, only a little higher than during the preceding year, though the fall of 1901 witnessed an increase.

Concerning sulfuric acid, the same authority states that the General Chemical Co. has kept prices at a satisfactory level. As the year advanced, prices were raised to meet the higher cost of raw material. In New York, prices were for 66 per cent. acid, $1.10—$1.30 per 100 lbs.; for 60 per cent. acid, 90 cents to $1.10 per 100 lbs., and for 50 per cent. acid in bulk $12.00 to $16.00 per ton.

During the fall of 1901, therefore, rock prices were considerably lower, acid prices slightly higher than in 1900. Valuation schedules must be based, however, upon the actual wholesale prices of the acid phosphates, rather than upon those of the raw materials from which they are made. New York wholesale quotations for acid

phosphate, per unit of available phosphoric acid, were, according to the *Oil, Paint and Drug Reporter* during 1900-1, 64.2 cts.; during 1901-2, 62.5 cts. According to the Engineering and Mining Journal, acid phosphate was offered, early this year, for 57.5 to 60.0 cents per unit; the retail selling prices in this State decreased from the spring to the fall of last year nearly 7 cents per unit.

Potash Salts: The reports of the U. S. Bureau of Statistics show the following entries for consumption during the fiscal years 1900 and 1901:

	1900	1901.
Muriate (pounds),	113,032,418	138,561,091
Kieserit, kainit, etc. (tons),	133,244	187,470

The German Potash Syndicate regulates the prices on potash salts and has held the 1902 schedule at the same level as that of 1901.

On the basis of large lots sold through brokers for cash and delivered at Boston, New York or Philadelphia, the schedules announced by the Syndicate are as follows.

Salt.	After March 1, 1900.	February, 1901.	After March 1, 1901.
Muriate:			
(80 to 85 per cent., 80 per cent. basis), cwt.,	$1 80	$1 80	$1 83
(95 per cent., 80 per cent. basis), cwt.,	....	1 83	1 86
Sulfate:			
(90 per cent., 90 per cent. basis), cwt.,	2.25	2 08	2 11
(96 per cent., 90 per cent. basis), cwt.,	....	2 11	2 14
Double manure salt (48 to 50 per cent., 48 per cent. basis), cwt.,	1 04	1 09	1 12
Kainit (12.4 per cent. actual potash) per ton at port of shipment,	8 80	8 80	....
Sylvinite (per unit potassium sulfate),	....	38-39	....
Manure salt (20 per cent. potash), per unit potash,	....	62-64	....

This trade is so managed that, before March 1, nearly all wholesale deliveries of the year are contracted for.

Composition of Raw Materials.

In order to form a correct idea of the cost per pound of the fertilizing constituents of these materials, it is needful to determine their composition; or, in other words, the quantities of valuable constituents each contains. The following table shows the composition of the raw materials used in the manufacture of fertilizers. Very

few analyses for these materials, with the exception of ground bone and dissolved rock, have been made in Pennsylvania. The figures in the following table include the averages of the results of analyses made in Connecticut, Massachusetts, New Jersey and Pennsylvania during the past year, except in the case of ground bone and dissolved rock phosphates, where Pennsylvania results alone are included.

Composition of Non-Acidulated Fertilizer Ingredients (Per Cent).

	Number of samples analyzed.	Nitrogen.	Potash.	Total phosphoric acid.
Sulfate of ammonia,	1	19.81	....	....
Nitrate of soda,	19	15.68	....	....
Dried blood,	6	11.43	....	....
Ground bone,	77	3.11	....	22.74
Tankage,	11	5.54	....	16.47
Ground fish,	15	7.61	....	6.49
Cotton seed meal,	46	7.24	1.90	3.15
Castor pomace,	5	5.01	.92	2.05
Sulfate of potash, high grade,	8	....	49.83	....
Muriate of potash,	30	....	50.43	....
Kainit,	4	....	13.44	....
Double sulfate of potash and magnesia,	8	....	26.47	....

Composition of Acidulated Fertilizer Ingredients (Per Cent).

	Number of samples analyzed.	Total phosphoric acid.	Soluble phosphoric acid.	Reverted phosphoric acid.	Insoluble phosphoric acid.
Dissolved bone-black,	5	16.75	12.53	2.81	1.41
Dissolved bone,*	6	17.55	2.03	6.70	8.82
Dissolved rock phosphate,	98	16.05	9.86	4.71	1.48

*Also contains 2.40 per cent. nitrogen.

The above figures, considering only those cases where a considerable number of analyses are available, would indicate that there has been no great change in the composition of the raw materials used in fertilizer manufacture.

Cost per Pound of Fertilizer Constituents.

From the foregoing data showing the cost per ton, hundredweight, or other unit of measure, of the several raw materials, and

the quantities of valuable constituents the average materials now on the market contain, the wholesale cost per pound of the valuable constituents can be readily estimated. In the case of ammoniates, the quotations are "per unit of ammonia" in many cases. The term "unit" is equivalent to "per cent.;" in goods sold by the ton of 2,000 lbs., the unit is equal to 20 lbs.; and 20 lbs. of ammonia contain 16.47 lbs. of nitrogen.

In the case of refuse bone-black, unacidulated, the mean, 28.25 per cent. of phosphoric acid, is assumed to represent the average material on the market.

Phosphate rock is sold by the ton of 2,240 lbs.; this material is sold on the basis of the bone-phosphate of lime it contains, with drawbacks for injurious constituents. Since the bone phosphate of lime contains 45.8 per cent. of phosphoric acid, each per cent. of bone phosphate in a long ton of phosphate rock is equivalent to 22.4 lbs. and contains 10.26 lbs. of phosphoric acid.

In the wholesale trade, it is customary to sell dried blood, azotine, horn and hoof meals, and concentrated tankage solely on the basis of ammonia, to the entire disregard of the phosphoric acid contained.

Likewise, the insoluble phosphoric acid in dissolved rock is omitted from consideration, and contracts are based solely upon the "available" phosphoric acid; that is, the sum of the "soluble" and "reverted" or "citrate soluble" phosphoric acid; nor in rock phosphates is any claim made for the small quantities of nitrogen and potash they always contain, nor in dissolved bone for the potash present.

Under these conditions, the wholesale cost per pound in New York of the valuable constituents of such materials as furnish but a single fertilizing element, these materials being assumed to be in the state of preparation and in the package in which the manufacturer purchased them, are given in the following table; also, a figure representing a fair retail price at the factory, the materials having undergone no change in treatment or packing, and the allowance for expense and profit in retailing being 20 per cent.

Wholesale Cost per Pound of Fertilizer Constituents (New York).
I. Ingredients Supplying One Constituent.

Material.	Constituent Valued.	Wholesale price. Cents.	Wholesale price plus 20 per cent.
Sulfate of ammonia,	Nitrogen,	14.30	17.16
Nitrate of soda,	Nitrogen,	12.68	15.22
Dried blood, high grade,	Nitrogen,	13.59	16.31
Concentrated tankage,	Nitrogen,	9.86	11.83
Refuse bone-black,	Phosphoric acid total,	3.36	4.03
*Phosphate rock:			
(Peace River, 60 per cent.),	Phosphoric acid total,	.41	.49
(Tennessee, 78 per cent.),	Phosphoric acid total,	.39	.47
(South Carolina, 60 per cent.),	Phosphoric acid total,	.53	.67
Acid phosphate,	Phosphoric acid available,	3.13	3.76
Double manure salts,	Potash,	4.20	5.04
Sulfate of potash,	Potash,	4.28	5.14
Muriate of potash,	Potash,	3.56	4.27
Kainit,	Potash,	3.55	4.26

*The prices of phosphate rock are f. o. b. at the respective points of shipment, not New York, and are taken from the reports of the Engineering and Mining Journal. The prices for potash are taken from the schedule of the Syndicate and those of the remainder from the Oil, Paint and Drug Reporter.

The quotations for bone are given without specific reference to quality, so that it is impossible from these data to fairly apportion their several wholesale values to the nitrogen and phosphoric acid contained in this material. As compared with tankage, the general tendency is to assign a higher commercial rating to the phosphoric acid in bone and to the nitrogen a rating not very different from that given in tankage.

The quotations of Thos. J. White and Company show an average wholesale rate in Baltimore during September, 1901, to March, 1902, for crushed tankage to have been $2.26 per unit of ammonia and $6.10 per unit of bone phosphate of lime. This is equivalent to $2.74 per unit of nitrogen and $0.218 per unit of phosphoric acid. The average composition of the ground bone and bone meal samples analyzed last fall in Pennsylvania was: Phosphoric acid, 22.53 per cent.; nitrogen, 2.94 per cent. The prepared bone contains less fat and moisture and often less nitrogen than the ordinary "rough bone;" but these differences tend, in a manner, to neutralize each other.

Assuming for the rough bone quoted in the New York market the same composition as the bone meal sold in Pennsylvania and for the value of the nitrogen $2.74 per unit, the values per pound of the several constituents would be:

Wholesale Cost per Pound of Fertilizer Constituents, New York.
II. Bone.

Grade.	Constituent Valued.	Wholesale price.	Wholesale price plus 20 per cent.
Rough bone,	Nitrogen,	13.7	16.4
	Phosphoric acid,	2.26	2.71
Ground bone,	Nitrogen,	15.39	18.42
	Phosphoric acid,	2.54	3.01

The average ground bone and bone meal on the retail market are probably inferior in composition to the rough bone on the wholesale market, hence these figures tend to be too high. Direct estimation of the wholesale pound values of acidulated bone (animal bone) cannot be made, as there are no wholesale data available for this purpose; for this computation, dependence must be placed upon the retail selling prices.

Valuations in Neighboring States.

It is desirable, from all points of view, that the schedules of valuation throughout a district in which similar market conditions prevail, should differ as little as possible. It has been our practice in the past, to conform our schedule to that adopted after very careful co-operative study of market conditions for each year, by the New England States and New Jersey, except where the peculiar conditions of our market have made the valuations diverge too largely from the actual selling prices, as in the case of ground bone and dissolved rock phosphates. The schedules for these States for 1900 and 1901 are as follows:

Trade Values Adopted by the New England States and New Jersey.

	Cents per lb. 1901.	Cents per lb. 1902.	Values of 1902 in per cent. of those of 1901.
Nitrogen:			
In ammonia salts,	16½	16½	100
In nitrates,	14	14	100
In dry and fine-ground fish,	16	16½	103.1
In meat, blood and mixed fertilizers,	16	16½	100
In fine-ground bone and tankage,	16	16½	100
In coarse bone and tankage,	12	12	100
Phosphoric acid:			
Water soluble,	5	5	100
Citrate soluble,	4½	4½	100
In cotton-seed meal, castor pomace and wood ashes,	4	4	100
In dry, fine-ground fish, bone and tankage,	4	4	100
In coarse fish, bone and tankage,	3	3	100
In mixed fertilizers, insoluble,	2	2	100
Potash:			
In forms free from muriate (chlorid),	5	5	100
As muriate,	4¼	4¼	100

Upon a careful consideration of the changes and tendencies of the wholesale prices of fertilizer ingredients and of the discrepancies occurring since the adoption of the 1901 schedule of valuation, it has been decided that the schedule for use during 1902 should be the same as that adopted for the use of New Jersey and New England, except at two points.

For reasons fully discussed in 1897, it is needful to include in the Pennsylvania schedule of valuations, a distinct set of values for phosphoric acid derived from rock as contrasted with that derived from animal materials. Reference to the tables, given on an earlier page, showing the wholesale cost of a pound of phosphoric acid, will make it plain that when it comes from phosphate rock, it costs the fertilizer maker about one-half to three-fourths of a cent at the mines, on the Atlantic seaboard; when from refuse bone-black, delivered at New York, 3.4 cents; when from tankage, about 1.1 cents; and from bone 2.69 cents.

There is nothing to indicate that, after acidulation, the available phosphoric acid from bone is at all better for the crop than that from a good rock lime-phosphate. But so long as the consumer is persuaded that bone phosphoric acid is worth more for his crop than an equal weight of rock phosphoric acid, just so long will the manufacturer of fertilizers be able to command a higher price for those fertilizers reputed to derive their phosphoric acid from bone, and just so long will he, in turn, be obliged to pay more for it on the wholesale market. Now, in some States, the volume of rock phosphoric

acid used is relatively small and the need for its separate valuation not apparent; in other States it predominates to the almost entire exclusion of bone phosphoric acid, so that no distinct valuation for the latter is required; but in Pennsylvania both occupy important positions upon the market and each requires its own set of values. Despite the slightly upward tendency of the acid phosphate market, it is thought needless to change the valuations of these constituents at this time, because the average valuations have, under the existing schedule, considerably exceeded the actual selling prices.

For similar reasons, nitrogen and phosphoric acid in ground bone are valued at lower rates in Pennsylvania than in New England. Owing to the fact that the bone valuations of the past year fell distinctly below the selling prices, a slight increase in the valuations of these goods has been made. Tankage is scheduled with bone, though costing less, because it is little sold at retail.

The schedule for 1902, as a whole, is as follows:

Schedule of Values for Fertilizer Ingredients, 1902.

	Cents per pound.
Nitrogen:	
In ammonia salts,	16½
In nitrates,	14
In meat, dried blood and mixed fertilizers,	16½
In cotton-seed meal and castor-pomace,	16½
In fine ground bone and tankage,	11
In coarse bone and tankage,	9
Phosphoric acid:	
Soluble in water, in bone fertilizers,	5
Soluble in water, in rock fertilizers,	3
Soluble in ammonium citrate, in bone fertilizers,	4½
Soluble in ammonium citrate in rock fertilizers,	2½
Insoluble in ammonium citrate, in bone fertilizers,	2
Insoluble in ammonium citrate, in r[illegible]	1½
In fine bone, tankage and fish,	3
In coarse bone and tankage,	2½
In cotton-seed meal, castor pomace and wood ashes,	4
Potash:	
In high-grade sulfate or in forms free from muriate,	5
As muriate,	4¼

Potash in excess of that equivalent to the chlorin present, will be valued as sulfate, and the remainder as muriate.

Nitrogen in mixed fertilizers will be valued as derived from the best sources of organic nitrogen, unless clear evidence to the contrary is obtained.

Phosphoric acid in mixed fertilizers is valued at bone phosphoric acid prices, unless clearly found to be derived from rock phosphate.

Bone is sifted into two grades of fineness: Fine, less than 1-50 inch in diameter; coarse, over 1-50 inch in diameter.

The result obtained by the use of this schedule does not cover the items of mixing, bagging, freight and agents' commission. To cover these, allowances are made as follows:

For freight, an allowance of $2.00 per ton on all fertilizers.

For bagging, an allowance of $1.00 per ton on all fertilizers, except when sold in original packages.

For mixing, an allowance of $1.00 per ton on complete fertilizers and rock-and-potash goods.

For agents' commission, an allowance of 20 per cent. is added to the cash values of the goods ready for shipment.

The mean quotation on freight from New Yoak, Philadelphia and Baltimore to Harrisburg, in January, 1897, was $1.68 per ton, in lots of twelve tons or over; in May, 1899, quotations by the Pennsylvania Railroad were: From New York, $2.40; from Philadelphia, $1.70; and from Baltimore, $1.55; mean rate from the three points, $1.88.

FERTILIZER ANALYSES, JANUARY 1 TO AUGUST 1, 1902.

Since January 1, 1902, there have been received from authorized sampling agents, eight hundred and thirty-eight (838) fertilizer samples, of which four hundred and fifty (450) were subjected to analysis, the remainder being rejected either because they represented brands analyzed last season, or because they were regarded as not certainly representative of the brand whose name they bore. When two or more samples representing the same brand were received, equal portions from the several samples were united and the composite sample was subjected to analysis.

The samples group themselves as follows: 289 complete fertilizers, furnishing phosphoric acid, potash and nitrogen; 2 dissolved bones, furnishing phosphoric acid and nitrogen; 66 rock-and-potash fertilizers, furnishing phosphoric acid and potash; 59 acidulated rock phosphates, furnishing phosphoric acid only; 29 ground bones, furnishing phosphoric acid and nitrogen; 5 miscellaneous fertilizers, which group includes potash salts, nitrate of soda and other substances not properly classified under the foregoing heads.

The determinations to which a complete fertilizer is subjected are

as follows: (1) Moisture, useful for the comparison of analyses, for indication of dry condition and fitness for drilling, and also of the conditions under which the fertilizer was kept in the warehouse. (2) Phosphoric acid—total, that portion soluble in water, and, of the residue, that portion not soluble in warm ammonium citrate solution (a solution supposed to represent the action of plant roots upon the fertilizer), which is assumed to have little immediate food value. By difference, it is easy to compute the so-called "reverted" acid, which is the portion insoluble in water but soluble in the citrate. The sum of the soluble and reverted is commonly called the "available" phosphoric acid. (3) Potash soluble in water,—most of that present in green sand marl and crushed minerals, and even some of that present in vegetable materials such as cotton-seed meal, not being included because insoluble in water even after long boiling. (4) Nitrogen—this element is determined by a method which simply accounts for all present, without distinguishing between the quantities present in the several forms of ammonium salts, nitrates or organic matter. (5) Chlorin; this determination is made to afford a basis for estimating the proportion of the potash that is present as chlorid or muriate, the cheaper source. The computation is made on the assumption that the chlorin present, unless in excess, has been introduced in the form of muriate of potash; but doubtless there are occasional exceptions to this rule. One part of chlorin combines with 1.326 parts of potash to form the pure muriate; knowing the chlorin, it is, therefore, easy to compute the potash equivalent thereto. (7) In the case of ground bone, the state of sub-division is determined by sifting through accurately made sieves; the cost of preparation and especially the promptness of action of bone in the soil depends very largely on the fineness of its particles, the finer being much more quickly useful to the plant.

The law having required the manufacturer to guarantee the amount of certain valuable ingredients present in any brand he may put upon the market, chemical analysis is employed to verify the guaranties stamped upon the fertilizer sacks. It has, therefore, been deemed desirable in this report to enter the guaranty filed by the manufacturer in the office of the Secretary of Agriculture, in such connection with the analytical results that the two may be compared. An unfortunate practice has grown up among manufacturers of so wording the guaranty that it seems to declare the presence in the goods of an amount of a valuable constituent ranging from a certain minimum to a much higher maximum; thus, "Potash, 2 to 4 per cent." is a guaranty not infrequently given. In reality, the sole guaranty is for 2 per cent. The guaranteed amounts given for each brand in the following tables, are copied from the guaranties filed by the maker of the goods with the Secretary of Agriculture, the lowest figure given

for any constituent being considered to be the amount guaranteed. For compactness and because no essentially important fact is suppressed thereby, the guaranties for soluble and reverted phosphoric acid have not been given separately, but are combined into a single guaranty for available phosphoric acid; in cases where the maker's guaranty does not specifically mention available phosphoric acid, the sum of the lowest figures given by him for soluble and reverted phosphoric acid is used. The law of 1879 allowed the maker to express his guaranty for nitrogen either in terms of that element or in terms of the ammonia equivalent thereto; since ammonia is composed of three parts of hydrogen and fourteen parts of nitrogen, it is a very simple matter to calculate the amount of one, when the amount of the other is given; the amount of nitrogen multiplied by 1.214 will give the corresponding amount of ammonia, and the amount of ammonia multiplied by 0.824 will give the corresponding amount of nitrogen. In these tables, the expression is in terms of nitrogen.

The law of 1901 abolishes this alternative and requires that the guaranty shall be given in terms of nitrogen. Many manufacturers after complying with the terms of the law, insert additional items in their guaranties, often with the result of misleading or confusing the buyer; the latter will do well to give heed to those items only that are given as the law requires and that are presented in these tables.

A summary of the analyses made this season may be presented as follows, excepting the miscellaneous class:

Summary of Analyses made this Season.

	Complete fertilizers.	Dissolved bone.	Rock and potash.	Dissolved rock.	Ground bone.
Number of analyses,	289	2	66	59	29
Moisture, per cent.,	8.93	7.83	10.90	9.06	5.89
Phosphoric acid:					
Total, per cent.,	10.77	12.96	11.89	15.88	22.22
Soluble, per cent.,	4.85	2.65	4.95	9.43	....
Reverted, per cent.,	3.41	4.45	5.37	4.65	....
Insoluble, per cent.,	2.51	5.86	1.57	1.80	....
Potash, per cent.,	3.97	....	3.69	....	....
Nitrogen, per cent.,	1.62	1.37	....	....	3.43
Mechanical analysis of bone:					
Fine,	....	....	....	....	69
Coarse,	....	....	....	....	31
Commercial valuation,	25.33	17.35	15.05	13.44	26.87
Average selling price,	24.10	16.50	16.45	13.73	28.52
Commercial value of samples whose selling price is ascertained,	25.33	17.35	15.05	13.49	26.80

Two tendencies appear upon a comparison between these data and the corresponding figures for the spring of 1901: A diminution of soluble phosphoric acid and a general increase in the percentages of reverted and insoluble phosphoric acid, while the total phosphoric acid is slightly increased; this tendency appeared in a great many brands. The use for acidulation of rock phosphates which, though richer in phosphoric acid, also contain more iron and alumina than heretofore, would account for this tendency, since the phosphates in acidulated goods from such rock tend to revert to insoluble forms. The second tendency is toward the greater use of potash, which appears in both complete fertilizers and rock-and-potash goods. The dissolved bones were very inferior.

The cases of departure of goods from their guaranteed composition observed this season, including only those cases in which it amounted to two-tenths per cent. or more, were as follows:

Summary of Instances of Deficiency from Guaranty.

	Complete fertilizers.	Dissolved bone.	Rock and potash.	Dissolved rock.	Ground bone.
Deficient in four constituents,	1	....	....	....	....
Deficient in three constituents,	6	....	....	....	....
Deficient in two constituents,	25	....	2	2	....
Deficient in one constituent,	83	2	18	7	5
Total samples in which deficiency occurred,	115	2	20	9	5

The cases of deficiency noted during the past seven seasons in the goods as compared with their guaranties, expressed in percentage of the total number of goods of each class analyzed, are as follows:

Percentages of Deficiency, 1899—1902.

	Spring, 1899.	Fall, 1899.	Spring, 1900.	Fall, 1900.	Spring, 1901.	Fall, 1901.	Spring, 1902.
Complete fertilizers,	38.4	33.7	42.0	40.8	31.6	34.6	40.00
Dissolved bone,	50.0	14.3	*50.0	*50.0	†	40.0	*100.00
Rock and potash,	19.1	34.2	29.2	33.3	31.7	26.2	30.3
Dissolved rock,	13.8	14.5	5.4	19.4	22.5	8.2	15.2
Ground bone,	18.4	25.3	36.7	11.8	34.1	18.2	17.2
All classes except miscellaneous,	30.9	29.2	35.2	34.3	30.8	27.6	34.2

*Only two samples analyzed.
†Only one sample analyzed.

Marked variations in the general percentages of deficiency occur from year to year. During the past season, they have been somewhat more numerous than usual. In most samples which are found below guaranty at one point, there is an excess at some other point, indicating that the cause of departure from the composition guaranteed lay not in the failure of the manufacturer to use the requisite components, but in his failure to secure a uniform mixture.

Considering all cases of complete fertilizers in which guaranties were strictly comparable with stated analytical results and sufficiently complete for the purpose: Of the one hundred and fifteen samples in which there was deficiency at some point, there were only seventeen in which there was not distinct excess above guaranty at some other point, though sometimes such excess was not sufficient to counter-balance the deficiency. Naturally, the tendency is toward excess of the cheaper constituent, phosphoric acid, and deficiency of potash or nitrogen, as appears below.

Two-thirds of the brands were up to or above guaranty at all points. The true average condition of the market for complete fertilizers will be more fairly exhibited by a comparison of the average composition of all samples for which guaranties are recorded with the average of the corresponding guaranties; they are as follows:

Average Composition and Guaranty Compared.

	Average composition. Per cent.	Average guaranty. Per cent.
Fall, 1901.		
Phosphoric acid:		
Total,	11.51	9.82
Available,	10.00	8.0[illegible]
Potash,	2.77	2.6[illegible]
Nitrogen,	1.39	1.39
Spring, 1902.		
Phosphoric acid:		
Total,	10.80	9.23
Available,	8.25	7.82
Potash,	3.90	3.66
Nitrogen,	1.62	1.58

It is of interest to note how closely the system of valuations, based upon the wholesale prices of raw materials in the principal markets during the most important buying season and upon certain average allowances for expense and profit on the part of the mixer and jobber, coincides with the retail prices later ascertained. A comparison for several seasons past is given below:

Comparison of Selling Price and Valuation, 1899—1902.

	Selling price.	Valuation.	Excess of valuation over selling price.
Complete fertilizers:			
1899, Spring,	$23.60	$24.70	$1.10
Fall,	22.98	23.42	.44
1900, Spring,	25.38	24.61	—.77
Fall,	23.22	23.84	.62
1901, Spring,	23.92	24.76	.84
Fall,	22.28	23.75	1.47
1902, Spring,	24.10	25.33	1.23
Dissolved bone:			
1899, Spring,	21.75	21.81	.06
Fall,	19.00	21.12	2.12
1900, Spring,	26.00	30.87	4.87
Fall,	23.50	22.74	—.76
1901, Spring,	28.00	29.00	1.00
Fall,	23.91	23.36	—.55
1902, Spring,	16.50	17.35	.85
Rock and potash:			
1899, Spring,	16.83	15.16	—1.67
Fall,	17.28	14.53	—2.75
1900, Spring,	17.35	14.71	—2.64
Fall,	18.11	14.63	—3.48
1901, Spring,	16.20	14.60	—1.60
Fall,	16.09	14.23	—1.86
1902, Spring,	16.45	15.05	—1.40
Dissolved rock:			
1899, Spring,	13.36	14.03	.67
Fall,	12.64	13.13	.49
1900, Spring,	13.57	13.48	—.09
Fall,	13.96	13.11	—.85
1901, Spring,	13.90	13.51	—.39
Fall,	13.18	13.82	.64
1902, Spring,	13.73	13.49	—.24
Ground bone:			
1899, Spring,	26.67	28.11	1.44
Fall,	24.98	27.23	2.25
1900, Spring,	28.42	25.91	—2.51
Fall,	28.73	26.87	—1.[illegible]6
1901, Spring,	27.59	28.71	1.12
Fall,	25.94	27.69	1.75
1902, Spring,	28.52	26.80	—1.72

The schedule of valuation adopted for use this year has given valuations agreeing well with the market prices of the spring trade; the only exceptions is in the case of ground bone in which the average valuation appears about as far below the average selling price, as it was above the latter under the schedule of 1901. The true relation can be ascertained only by taking into account the average freight to points of sale from which samples were taken this year. Rock-and-potash selling prices are always high in comparison with those of complete fertilizers, but the disparity seems to be diminishing.

The results of the United States Census relative to manufactures being now available, some facts of especial interest respecting the fertilizer trade appear. Prior to the consideration of these data, a comparison of the average composition of the complete fertilizers analyzed by this Control in 1890 and 1900 is given:

	1890. Per cent.	1900. Per cent.
Moisture,	12.20	9.11
Phosphoric acid:		
Total,	12.47	10.80
Soluble,	6.36	4.87
Reverted,	2.98	3.62
Insoluble,	3.12	2.31
Potash,	3.04	3.43
Nitrogen,	1.86	1.67
Valuation,	$2[illegible].06	$24.[illegible]
Selling price,	28.64	21.68

That is to say, one dollar bought in complete fertilizers at the two periods the following quantities of the valuable constituents:

	1890. Pounds.	1900. Pounds.
Phosphoric acid,	8.71	8.7[illegible]
Potash,	2.12	2.78
Nitrogen,	1.29	1.35

That is, for the same money, the retail purchaser secured in 1900 about the same amount of phosphoric acid, thirty-one per cent. more potash and nearly five per cent. more nitrogen than in 1890.

A brief summary of the Census statistics for 1890 and 1900 showing the values involved in the fertilizer manufacture of the United States is as follows:

	1890.	1900.
Number of establishments,	390	422
Capital,	$40,594,168	$60,685,763
Wage earners employed,	9,026	11,581
Wages paid (total),	$3,417,870	$4,1[illegible]9
Miscellaneous expenses,	$2,790,012	$3,734,285
Cost of materials used,	$25,113,874	$28,958,473
Value of products,	$39,180,844	$44,657,385

From these the following comparative statement for the two periods is derived:

	1890.	1900.
Average wages paid each wage earner,	$378.67	$361.39
Capital invested for each $1 of raw material manufactured,	1.62	2.10
Cost of manufacturing $1 of raw material into finished products:		
Cost of raw material,	$1.00	$1.00
Interest on capital corresponding,	.081	.105
Wages,	.136	.145
Miscellaneous expenses,	.111	.128
Total cost,	$1.328	$1.378
Estimated value of products,	$1.560	$1.543

In general, that is, the stated cost of manufacture has increased during the decade, about 4 per cent., while the estimated value of the product has fallen between one and two per cent., the net profits being 17.5 per cent. of the cost of production in 1890 and 11.9 per cent. in 1900.

This decrease in net profit is due chiefly to increased cost of production. A little more than one-fourth of the increase occurs in the item of miscellaneous expenses, including insurance, interest, taxes, etc.; almost an equal fraction of the increase is due to the smaller earning efficiency of $1 spent in wages (including salaries), despite the fact that the average wages paid to each earner is 7.5 per cent. less than in 1890. One-half of the whole increase is attributable, however, to the interest item on the stated capitalization, which has increased almost thirty per cent. for each dollar's worth of raw material used.

This stated increase is distributed as follows, in terms of the items for 1890:

	Per cent.
Land,	28.2
Buildings,	54.3
Machinery and implements,	56.4
Total plant,	49.1
Cash and sundries,	49.7

This increase of stated capitalization, proportionally so much greater than the increase in the cost of raw materials and the value of finished products, naturally raises a question as to how much of the stated capital represents money invested. This is at present a question for stock buyers. It is sufficient to the consumer to know that, as compared with 1890, he was in 1900 able to purchase more

fertilizer for one dollar; and that whereas in 1890 he was obliged to pay at the factory 56 cents advance upon every dollar's worth of raw material used by the manufacturer, in 1900 the advance was only 54.3 cents.

The foregoing advances are not comparable with those allowed in the schedule of valuations to the mixer, for the cost of acidulation is excluded in the latter case, having been already included in the wholesale value of the acid rock and dissolved bone.

The analytical work has been performed by the following assistant chemists: Nitrogen, Mr. M. S. McDowell; soluble and insoluble phosphoric acid, Mr. C. W. Norris; potash and chlorin, Mr. M. H. Pingree; moisture and total phosphoric acid, Mr. N. W. Buckhout. The listing and preparation of samples were in charge of Mr. McDowell; the computation and care of records in charge of Misses M. Garner and E. F. Jones.

Respectfully submitted,

WM. FREAR.

August 5, 1902.

FERTILIZER ANALYSES, AUGUST 1 TO DECEMBER 31, 1902.

Since August 1, 1902, there have been received from authorized sampling agents, six hundred and three fertilizer samples, of which all but two were subjected to analysis, these two being rejected because of insufficient description. When two or more samples representing the same brand were received, equal portions from the several samples were united and the composite sample was subjected to analysis.

The samples group themselves as follows: 229 complete fertilizers, furnishing phosphoric acid, potash and nitrogen; 6 dissolved bones, furnishing phosphoric acid and nitrogen; 62 rock-and-potash fertilizers, furnishing phosphoric acid and potash; 56 acidulated rock phosphates, furnishing phosphoric acid only; 27 ground bones, furnishing phosphoric acid and nitrogen; 2 miscellaneous fertilizers, which group includes potash salts, nitrate of soda and other substances not properly classified under the foregoing heads.

The determinations to which a complete fertilizer is subjected are as follows: (1) Moisture, useful for the comparison of analyses, for indication of dry condition and fitness for drilling, and also of the conditions under which the fertilizer was kept in the warehouse. (2)

Phosphoric acid—total, that portion soluble in water, and, of the residue, that portion not soluble in warm ammonium citrate solution (a solution supposed to represent the action of plant roots upon the fertilizer), which is assumed to have little immediate food value. By difference, it is easy to compute the so-called "reverted" acid, which is the portion insoluble in water but soluble in the citrate. The sum of the soluble and reverted is commonly called the "available" phosphoric acid. (3) Potash soluble in water,—most of that present in green sand marl and crushed minerals, and even some of that present in vegetable materials such as cotton-seed meal, not being included because insoluble in water even after long boiling. (4) Nitrogen—this element is determined by a method which simply accounts for all present, without distinguishing between the quantities present in the several forms of ammonium salts, nitrates or organic matter. (5) Chlorin; this determination is made to afford a basis for estimating the proportion of the potash that is present as chlorid or muriate, the cheaper source. The computation is made on the assumption that the chlorin present, unless in excess, has been introduced in the form of muriate of potash; but doubtless there are occasional exceptions to this rule. One part of chlorin combines with 1.326 parts of potash to form the pure muriate; knowing the chlorin, it is, therefore, easy to compute the potash equivalent thereto. (7) In the case of ground bone, the state of sub-division is determined by sifting through accurately made sieves; the cost of preparation and especially the promptness of action of bone in the soil depends very largely on the fineness of its particles, the finer being much more quickly useful to the plant.

The law having required the manufacturer to guarantee the amount of certain valuable ingredients present in any brand he may put upon the market, chemical analysis is employed to verify the guaranties stamped upon the fertilizer sacks. It has, therefore, been deemed desirable in this report to enter the guaranty filed by the manufacturer in the office of the Secretary of Agriculture, in such connection with the analytical results that the two may be compared. An unfortunate practice has grown up among manufacturers of so wording the guaranty that it seems to declare the presence in the goods of an amount of valuable constituent ranging from a certain minimum to a much higher maximum; thus, "Potash, 2 to 4 per cent.," is a guaranty not infrequently given. In reality, the sole guaranty is for 2 per cent. The guaranteed amounts given for each brand in the following tables, are copied from the guaranties filed by the maker of the goods with the Secretary of Agriculture, the lowest figure given for any constituent being considered to be the amount guaranteed. For compactness and because no essentially important fact is suppressed thereby, the guaranties for soluble and reverted

phosphoric acid have not been given separately, but are combined into a single guaranty for available phosphoric acid; in cases where the maker's guaranty does not specifically mention available phosphoric acid, the sum of the lowest figures given by him for soluble and reverted phosphoric acid is used. The law of 1879 allowed the maker to express his guaranty for nitrogen either in terms of that element or in terms of the ammonia equivalent thereto; since ammonia is composed of three parts of hydrogen and fourteen parts of nitrogen, it is a very simple matter to calculate the amount of one, when the amount of the other is given; the amount of nitrogen multiplied by 1.214 will give the corresponding amount of ammonia, and the amount of ammonia multiplied by 0.824 will give the corresponding amount of nitrogen. In these tables, the expression is in terms of nitrogen.

The law of 1901 abolishes this alternative and requires that the guaranty shall be given in terms of nitrogen. Many manufacturers after complying with the terms of the law, insert additional items in their guaranties, often with the result of misleading or confusing the buyer; the latter will do well to give heed to those items only that are given as the law requires and that are presented in these tables.

A summary of the analyses made this season may be presented as follows, excepting the miscellaneous class:

Summary of Analyses made this Season.

	Complete fertilizers.	Dissolved bone.	Rock and potash.	Dissolved rock.	Ground bone.
Number of analyses,	229	5	62	56	[illegible]
Moisture, per cent.,	9.34	5.73	10.59	9.04	5.72
Phosphoric acid:					
Total, per cent.,	11.06	15.56	12.02	16.13	23.47
Soluble, per cent.,	4.35	0.65	5.82	9.78	....
Reverted, per cent.,	3.34	7.22	4.78	4.96	....
Insoluble, per cent.,	2.37	5.00	1.42	1.39	....
Potash, per cent.,	2.55	....	2.37	....	3.25
Nitrogen, per cent.,	[illegible]	[illegible]	....	....	....
Mechanical analysis of bone:					
Fine,	....	....	....	....	70
Coarse,	....	....	....	....	35
Commercial valuation,	$23.43	$27.65	$14.39	$13.72	$27.32
Average selling price,	21.53	25.60	15.95	13.47	28.09
Commercial value of samples whose selling price is ascertained,	23.31	27.06	14.46	13.79	27.51

The cases of departure of goods from their guaranteed composition observed this season, including only those cases in which it amounted to two-tenths per cent. or more, were as follows:

Summary of Instances of Deficiency from Guaranty.

	Complete fertilizers.	Dissolved bone.	Rock and potash.	Dissolved rock.	Ground bone.
Deficient in four constituents,	...	...	...	...	...
Deficient in three constituents,	6	...	...	...	...
Deficient in two constituents,	35	1	2	2	1
Deficient in one constituent,	43	2	25	3	6
Total samples in which deficiency occurred,	84	3	27	5	7

The cases of deficiency noted during the past eight seasons in the goods as compared with their guaranties expressed in percentage of the total number of goods of each class analyzed, are as follows:

Percentage of Deficiency, 1899-1902.

	Spring, 1899	Fall, 1899.	Spring, 1900.	Fall, 1900.	Spring, 1901.	Fall, 1901.	Spring, 1902.	Fall, 1902.
Complete fertilizers,	38.4	33.7	42.0	40.8	31.6	34.6	40.0	36.7
Dissolved bone,	50.0	14.3	*50.0	*50.0	†	40.0	*100.0	50.0
Rock and potash,	19.1	34.2	29.2	33.3	31.7	26.2	30.3	43.5
Dissolved rock,	13.8	14.5	5.4	19.4	22.5	8.2	15.2	8.9
Ground bone,	18.4	25.3	36.7	11.8	34.1	18.2	17.2	25.9
All classes except miscellaneous,	30.9	29.2	35.2	34.3	30.8	27.6	34.2	33.2

*Only two samples analyzed.
†Only one sample analyzed.

Marked variations in the general percentages of deficiency occur from year to year. During the past season they have been slightly above normal. In most samples which are found below guaranty at one point, there is an excess at some other point, indicating that the cause of departure from the composition guaranteed lay not in the failure of the manufacturer to use the requisite components, but in his failure to secure a uniform mixture.

Considering all cases of complete fertilizers in which guaranties were strictly comparable with stated analytical results and sufficiently complete for the purpose: Of the one hundred and twenty-six (126) samples in which there was deficiency at some point, there were twenty-four (24) in which there was not distinct excess above guaranty at some other point, though sometimes such excess was

not sufficient to counterbalance the deficiency. Naturally, the tendency is towards excess of the cheaper constituent, phosphoric acid, and deficiency of potash or nitrogen, as appears below.

As heretofore, about two-thirds of the brands are up to or above guaranty at all points. The true average condition of the market for complete fertilizers will be more fairly exhibited by a comparison of the average composition of all samples for which guaranties are recorded with the average of the corresponding guaranties; they are as follows:

Average Composition and Guaranty Compared.

	Average composition. Per cent.	Average guaranty. Per cent.
Fall, 1901.		
Phosphoric acid:		
Total,	11.51	9.82
Available,	10.60	8.06
Potash,	2.77	2.66
Nitrogen,	1.39	1.39
Spring, 1902.		
Phosphoric acid:		
Total,	10.80	9.29
Available,	8.25	7.82
Potash,	3.90	3.66
Nitrogen,	1.62	1.58
Fall, 1902.		
Phosphoric acid:		
Total,	12.58	11.40
Available,	9.95	9.29
Potash,	2.69	2.60
Nitrogen,	1.57	1.55

It is of interest to note how closely the system of valuations, based upon the wholesale prices of raw materials in the principal markets during the most important buying season and upon certain average allowances for expense and profit on the part of the mixer and jobber, coincides with the retail prices later ascertained. A comparison for several seasons past is given below:

Comparison of Selling Price and Valuation, 1899-1902.

	Selling price.	Valuation.	Excess of valuation over selling price.
Complete fertilizers:			
1899, Spring,	$23.60	$24.70	$1.10
Fall,	22.98	23.42	.44
1900, Spring,	25.38	24.61	—.77
Fall,	23.22	23.84	.62
1901, Spring,	23.92	24.76	.84
Fall,	22.28	23.75	1.47
1902, Spring,	24.10	25.33	1.23
Fall,	21.83	23.31	1.48
Dissolved bone:			
1899, Spring,	21.75	21.81	.06
Fall,	19.00	21.12	2.12
1900, Spring,	26.00	30.87	4.87
Fall,	23.50	22.74	—.76
1901, Spring,	28.00	29.00	1.00
Fall,	23.91	23.36	—.55
1902, Spring,	16.50	17.35	.85
Fall,	25.30	27.08	1.78
Rock and potash:			
1899, Spring,	$16.83	$15.16	$—1.67
Fall,	17.28	14.53	—2.75
1900, Spring,	17.35	14.71	—2.64
Fall,	18.11	14.63	—3.48
1901, Spring,	16.20	14.60	—1.60
Fall,	16.09	14.23	—1.86
1902, Spring,	16.45	15.05	—1.40
Fall,	15.97	14.46	—1.51
Dissolved rock:			
1899, Spring,	13.36	14.03	.67
Fall,	12.64	13.13	.49
1900, Spring,	13.57	13.48	—.09
Fall,	13.96	13.11	—.85
1901, Spring,	13.90	13.51	—.39
Fall,	13.18	13.82	.64
1902, Spring,	13.73	13.49	—.24
Fall,	13.54	13.70	.12
Ground bone:			
1899, Spring,	26.67	28.11	1.44
Fall,	24.98	27.23	2.25
1900, Spring,	28.42	25.91	—2.51
Fall,	28.73	26.87	—1.86
1901, Spring,	27.59	28.71	1.12
Fall,	25.94	27.69	1.75
1902, Spring,	28.52	26.80	—1.72
Fall,	28.09	27.51	—.58

The work herein reported was performed by my assistants as follows: Determination of total phosphoric acid, Messrs. Leonard R. Cooke and Firman Thompson; soluble and insoluble phosphoric acid, Messrs. Thorne M. Carpenter and H. D. Edmiston; potash and chlorin, Mr. M. H. Pingree; nitrogen, Mr. H. E. Wilson; computation of values and compilation of bulletin, Messrs. M. S. McDowell, T. M. Carpenter, W. M. Darrow, and Miss E. F. Jones, to each of whom my thanks are due for zealous co-operation.

Very respectfully,

WM. FREAR.

State College, Pa., December 31, 1902.

LIST OF FERTILIZER MANUFACTURERS AND BRANDS OF FERTILIZERS LICENSED FOR SALE IN PENNSYLVANIA FOR THE YEAR 1902.

THE ABBOTT & MARTIN RENDERING CO., No. 232 N. High Street, Columbus, Ohio.

1. "Ideal Grain Grower."
2. "Peerless Bone and Potash."
3. "Harvest King."
4. "Abbott's Tobacco and Potato Special."
5. "New York Special."
6. "Standard Phosphate."
7. "Star Phosphate."
8. "Benders Bone Meal."

AHRENS, C. K. Esterley, Pa.

1. "Bone Meal."

ALLEGHENY CITY FERTILIZER WORKS, Allegheny, Pa.

1. "Pure Raw Bone Phosphate."
2. "Pure Raw Bone Meal."
3. "Potato Manure."
4. "Banner Phosphate."
5. "Dissolved Bone and Potash."
6. "Odorless Lawn and Garden Plant Food."
7. "Full Value Phosphate."
8. "Butcher's Bone Meal."
9. "Bone Meal."
10. "Grain and Grass Phosphate."
11. "Special Potash and Phosphate."
12. "Acid Phosphate."

THE ALLENTOWN MANUFACTURING CO., Allentown, Pa.

1. "High Grade Truck and Garden Phosphate."
2. "High Grade Potato Phosphate."
3. "Complete Bone Phosphate."
4. "Special $25.00 Phosphate."
5. "Phosphate and Potash."
6. "Pure Ground Bone."
7. "Acidulated Phosphate."
8. "Economical Phosphate."
9. "Pure Bone and Meal."

AMERICAN REDUCTION CO., No. 1942 Forbes Street, Pittsburg, Pa.

1. "Pittsburg Guano."
2. "Iron City."
3. "Common Sense."
4. "Vegetable Manure."
5. "Fine Ground Bone."

THE AMERICAN AGRICULTURAL CHEMICAL CO., No. 326 Broadway, New York, N. Y.

1. "Pure Ground Bone."
2. "Fine Ground Bone."
3. "Bone Meal."
4. "Muriate of Potash."
5. "Genuine German Kainit."
6. "Dissolved Animal Bone."
7. "Gem Alkaline Bone."

THE A. A. C. CO., BRADLEY'S BRANCH, P. O. Box 217, New York, N. Y.

1. "Bradley's Dissolved Bone and Potash."
2. "Bradley's Bean and Potato Phosphate."
3. "Bradley's Soluble Dissolved Bone."
4. "Bradley's Niagara Phosphate."
5. "Bradley's Alkaline Bone with Potash."
6. "Bradley's B. D. Sea Fowl Guano."

THE A. A. C. CO., CANTON CHEMICAL BRANCH, P. O. Box 407, Baltimore, Md.

1. "Canton-Chemical C. C. C. Special Compound."
2. "Canton-Chemical Baker's Standard H. G. Guano."
3. "Canton-Chemical Baker's Fish Guano."
4. "Canton-Chemical Potato Manure."
5. "Canton-Chemical B. G. Ammoniated Bone."
6. "Canton-Chemical Resurgam Guano."
7. "Canton-Chemical Baker's Special Wheat, Corn and Grass Mixture."
8. "Canton-Chemical Harrow Brand Crop Grower."
9. "Canton-Chemical Eagle Phosphate."
10. "Canton-Chemical Soluble Alkaline Bone."
11. "Canton-Chemical Soluble Bone and Potash."
12. "Canton-Chemical Baker's Dissolved Bone Phosphate."
13. "Canton-Chemical Baker's Dissolved S. C. Bone."

THE A. A. C. CO., CHICOPEE GUANO BRANCH, No. 88 Wall Street, New York, N. Y.

1. "Chicopee Farmer's Reliable."
2. "Chicopee Standard Guano."

THE A. A. C. CO., CLARK'S COVE BRANCH, P. O. Box 1779, New York, N. Y.

1. "Clark's Cove Atlas Bone Phosphate."
2. "Clark's Cove Triumph Bone and Potash."
3. "Clark's Cove Defiance Complete Manure."
4. "Clark's Cove King Philip Alkaline Guano."
5. "Clark's Cove Potato and Hop Grower."

THE A. A. C. CO., CROCKER BRANCH, Buffalo, N. Y.

1. "Crocker's General Crop Grower."
2. "Crocker's Universal Grain Grower."
3. "Crocker's Complete Manure."
4. "Crocker's Complete New Rival Fertilizer."

5. "Crocker's Wheat and Corn Fertilizer."
6. "Crocker's Potato, Hop and Tobacco Fertilizer."
7. "Crocker's Ammoniated Bone Super-Phosphate."
8. "Crocker's Dissolved Bone and Potash."
9. "Crocker's Dissolved Bone Phosphate."

THE A. A. C. CO., CUMBERLAND BRANCH, No. 27 William Street, New York, N. Y.

1. "Cumberland Dissolved Bone Phosphate."
2. "Cumberland Bone and Potash."
3. "Cumberland Hawkeye Fertilizer."

THE A. A. C. CO., DETRICK BRANCH, No. 26 Chamber of Commerce, Baltimore, Md.

1. "Detrick's Quickstep Bone Phosphate for Potatoes and Tobacco."
2. "Detrick's Kangaroo Komplete Kompound."
3. "Detrick's Royal Crop Grower."
4. "Detrick's Standard Potash Fertilizer."
5. "Detrick's Corn and Oats Fertilizer."
6. "Detrick's Imperial Compound."
7. "Detrick's Paragon Ammoniated Bone Phosphate and Potash."
8. "Detrick's P. & B. Special Fertilizer."
9. "Detrick's Bone and Potash (16x4) Mixture."
10. "Detrick's Soluble Bone Phosphate and Potash."
11. "Detrick's Dissolved S. C. Bone."
12. "Orchilla Guano."

THE A. A. C. CO., GREAT EASTERN BRANCH, Rutland, Vt.

1. "Great Eastern Northern Corn Special."
2. "Great Eastern Vegetable, Vine and Tobacco."
3. "Great Eastern Wheat Special."
4. "Great Eastern General."
5. "Great Eastern English Wheat Grower."
6. "Great Eastern Soluble Bone and Potash."
7. "Great Eastern Dissolved Bone."
8. "Great Eastern Unammoniated Wheat Special."
9. "Great Eastern High Grade Cabbage Grower."

THE A. A. C. CO., LAZARETTO GUANO BRANCH, Merchant's Bank Building, Baltimore, Md.

1. "Lazaretto Crop Grower."
2. "Lazaretto Bone Compound."
3. "Lazaretto Special Potato Fertilizer."
4. "Lazaretto Ammoniated Bone Phosphate."
5. "Lazaretto Excelsior A. A. A."
6. "Lazaretto Dissolved Bone and Potash."
7. "Lazaretto Dissolved Bone Phosphate."
8. "Lazaretto H. G. Dissolved Bone and Potash."

THE A. A. C. CO., MARYLAND BRANCH, No. 30 S. Holliday Street, Baltimore, Md.

1. "Maryland Ammoniated Bone."
2. "Maryland O. K. Ammoniated Fertilizer."
3. "Maryland Alkaline Bone."
4. "Maryland Linden Super-Phosphate."
5. "Maryland Bono Super-Phosphate."
6. "Maryland Dissolved S. C. Phosphate."
7. "Maryland Compound for Potatoes and Tobacco."

THE A. A. C. CO., MICHIGAN CARBON WORKS BRANCH, Detroit, Mich.

1. "Red Line Phosphate."
2. "Red Line Phosphate with Potash."
3. "Red Line Complete Manure."
4. "General Crop Fertilizer."
5. "Homestead "A" Bone Black Fertilizer."

THE A. A. C. CO., MILSOM BRANCH, East Buffalo, N. Y.

1. "Milsom's Erie King Fertilizer."
2. "Milsom's Wheat, Oats and Barley Fertilizer."
3. "Milsom's Buffalo Guano."
4. "Milsom's Buffalo Fertilizer."
5. "Milsom's Potato, Hop and Tobacco Fertilizer."
6. "Milsom's Corn Fertilizer."
7. "Milsom's Vegetable Bone Fertilizer."
8. "Milsom's Dissolved Bone and Potash."
9. "Milsom's Acid Phosphate."
10. "Milsom's Dissolved Bone Phosphate."

THE A. A. C. CO., MORO-PHILLIPS BRANCH, No. 708 The Bourse, Phila delphia, Pa.

1. "Moro-Phillips Pure Phuine."
2. "Moro-Phillips Soluble Bone Phosphate."
3. "Moro-Phillips Wheat Special."
4. "Moro-Phillips Farmers' Phosphate."
5. "Moro-Phillips Farmers' Potato Mixture."
6. "Moro-Phillips Alkaline Bone Phosphate."
7. "Moro-Phillips Special Fertilizer."
8. "Moro-Phillips C. & G. Complete Fertilizer."
9. "Moro-Phillips Standard Guano."

THE A. A. C. CO., NIAGARA BRANCH, P. O. Box 189, Buffalo, N. Y.

1. "Niagara Grain and Grass Grower."
2. "Niagara Wheat and Corn Producer."
3. "Niagara Dissolved Bone and Potash."
4. "Niagara Dissolved Bone Phosphate."

THE A. A. C. CO., PACIFIC GUANO BRANCH, P. O. Box 2350, New York, N. Y.

1. "Pacific Dissolved Bone Phosphate."
2. "Pacific Dissolved Bone and Potash."

3. "Pacific A. No. 1 Phosphate."
4. "Pacific Nobsque Guano."
5. "Pacific Potato Phosphate."

THE A. A. C. CO., PACKERS UNION BRANCH, Rutland, Vt.

1. "Packers Union Gardeners' Complete Manure."
2. "Packers Union Animal Corn Fertilizer."
3. "Packers Union Potato Manure."
4. "Packers Union Universal Fertilizer."
5. "Packers Union American Wheat and Rye Grower."
6. "Packers Union Banner Wheat Grower."
7. "Packers Union Acidulated Bone."
8. "Packers Union Wheat, Oats and Clover."

THE A. A. C. CO., QUINNIPIAC BRANCH, No. 27 William Street, New York, N. Y.

1. "Quinnipiac Soluble Dissolved Bone."
2. "Quinnipiac Dissolved Bone and Potash."
3. "Quinnipiac Mohawk Fertilizer."
4. "Quinnipiac Climax Phosphate."

THE A. A. C. CO., READ BRANCH, No. 88 Wall Street, New York, N. Y.

1. "Read's Standard Super-Phosphate."
2. "Read's Leader Blood and Bone."
3. "Read's Farmers' Friend Super-Phosphate."
4. "Read's Acid Phosphate (14 Per Cent.)."
5. "Read's Bone and Potash."

THE A. A. C. CO., REESE BRANCH, Equitable Building, Baltimore, Md.

1. "Reese's Standard."
2. "Reese's Potato Phosphate."
3. "Reese's Mayflower."
4. "Reese's Potato Manure."
5. "Reese's Ammoniated Bone Phosphate Mixture."
6. "Reese's Harvest Queen."
7. "Reese's Pilgrim Fertilizer."
8. "Reese's Challenge Crop Grower."
9. "Reese's Half and Half."
10. "Reese's High Grade Potash Mixture, 12x5."
11. "Reese's Crown Phosphate and Potash."
12. "Reese's Grass and Grain."
13. "Reese's Wheat Special."
14. "Reese's Dissolved Phosphate of Lime."
15. "Reese's Elm Phosphate."

THE A. A. C. CO., SHARPLESS & CARPENTER BRANCH, No. 124 S. Delaware Avenue, Philadelphia, Pa.

1. "Sharpless & Carpenter Corn and Truck Guano."
2. "Sharpless & Carpenter Farmers' Imp. Potato Manure."
3. "Sharpless & Carpenter Gilt Edge Potato and Tobacco Manure."
4. "Sharpless & Carpenter No. 1 Bone Phosphate."

5. "Sharpless & Carpenter Royal Spring Mixture."
6. "Sharpless & Carpenter Soluble Bone and Potash."
7. "Sharpless & Carpenter Farmers' Bone Phosphate."
8. "Sharpless & Carpenter Dis. Bone Phos. for Potatoes and General Use.
9. "Sharpless & Carpenter No. 2 for Grain and Grass."
10. "Sharpless & Carpenter Soluble Tampico Guano."
11. "Sharpless & Carpenter Acid Phosphate."

THE A. A. C. CO., STANDARD BRANCH, No. 40 Exchange Place, New York, N. Y.

1. "Standard Dissolved Bone Phosphate."
2. "Standard Bone and Potash."
3. "Standard "A" Fertilizer."
4. "Standard Guano."

THE A. A. C. CO., SUSQUEHANNA BRANCH, Cor. South and Water Streets, Baltimore, Md.

1. "Susquehanna Potato Phosphate."
2. "Susquehanna Pure Bone Phosphate."
3. "Susquehanna Ammoniated Bone Phosphate."
4. "Susquehanna XXV Phosphate."
5. "Susquehanna Crop Grower."
6. "Susquehanna High Grade Bone and Potash."
7. "Susquehanna Alkaline Bone Phosphate."
8. "Susquehanna Superior Rock Phosphate."
9. "Susquehanna Soluble Bone Phosphate."

THE A. A. C. CO., TYGERT-ALLEN BRANCH, No. 708 The Bourse, Philadelphia, Pa.

1. "Tygert-Allen Star Guano."
2. "Tygert-Allen Star Potato Grower."
3. "Tygert-Allen Star Dissolved Bone Phosphate."
4. "Tygert-Allen Star Soluble Bone and Potash."
5. "Tygert-Allen Star Bone Phosphate."
6. "Tygert-Allen Standard Bone Phosphate."
7. "Howitz's Acid Phosphate."
8. "Allen's Popular Phosphate."
9. "Allen's Special Brand Potato Manure."
10. "Allen's Special for Wheat and Grass."
11. "Allen's Nitro Phosphate."
12. "Allen's Alkaline Bone Phosphate."
13. "Yearsley's Philadelphia Standard Phosphate."

THE A. A. C. CO., M. E. WHEELER & CO. BRANCH, Rutland, Vt.

1. "Wheeler's Corn Fertilizer."
2. "Wheeler's Potato Manure."
3. "Wheeler's Superior Truck."
4. "Wheeler's Royal Wheat Grower."
5. "Wheeler's Wheat and Clover Fertilizer."
6. "Wheeler's Electrical Dissolved Bone."
7. "Wheeler's Unammoniated Wheat Grower."

THE A. A. C. CO., WILLIAMS & CLARK BRANCH, No. 27 William Street, New York, N. Y.

1. "Williams & Clark Acorn Acid Phosphate."
2. "Williams & Clark Dissolved Bone and Potash."
3. "Williams & Clark Prolific Fertilizer."
4. "Williams & Clark Royal Bone Phosphate."
5. "Williams & Clark Americus High Grade Special."
6. "Williams & Clark Americus Universal Ammoniated Dis. Bone."
7. "Williams & Clark Good Grower Potato Phosphate."

THE A. A. C. CO., ZELL GUANO BRANCH, No. 32 South Street, Baltimore, Md.

1. "Zell's Special Compound for Potatoes and Vegetables."
2. "Zell's Ammoniated Bone Super-Phosphate."
3. "Zell's Hustler Phosphate."
4. "Zell's Economizer Phosphate."
5. "Zell's Little Giant."
6. "Zell's Dissolved Bone Phosphate and Potash."
7. "Zell's Electric Phosphate."
8. "Zell's Dissolved Bone Phosphate."

ANSTINE, A., Stewartstown, Pa.

1. "Bone Phosphate."

THE ARMOUR FERTILIZER WORKS, No. 205 LaSalle Street, Chicago, Ill.

1. "Bone Meal."
2. "Raw Bone Meal."
3. "Phosphate and Potash."
4. "Wheat, Corn and Oats Special."
5. "Ammoniated Bone and Potash."
6. "Fruit and Root Crop Special."
7. "All Soluble."
8. "Bone, Blood and Potash."
9. "Armour's Royal Amm. Bone."
10. "High Grade Potash."
11. "Grain Grower."
12. "Star Phosphate."
13. "Cereal Phosphate."
14. "Phosphate and Potash No. 2."
15. "Armour's Wheat Special."
16. "Special Mixture."

AUCKER, R. S., Shamokin, Pa.

1. "Bone Meal."
2. "Bone Meal with Potash."
3. "High Grade Bone and S. H. Phosphate."
4. "Grade A. Bone and Slaughter House Phosphate."
5. "Grade B. Bone and Slaughter House Phosphate."
6. "Grade D. Bone and Slaughter House Phosphate."
7. "Grade E. Bone and Slaughter House Phosphate."
8. "Economy Potash Phosphate."
9. "High Grade Acid Phosphate."

BALTIMORE PULVERIZING COMPANY, Nos. 13 and 15 North Street, Baltimore, Md.

1. "Penniman's Excelsior Fertilizer."
2. "Farmer's Favorite Fertilizer."
3. "Special Spring and Fall Mixture."
4. "Penniman's Special Guano."
5. "Truckers' Choice."
6. "South Carolina Bone Phosphate."

BARTENSCHLAGER, J. H., Stewartstown, Pa.

1. "Bartenschlager's Champion Bone Phosphate."

BAUGH & SONS COMPANY, No. 20 S. Delaware Avenue, Philadelphia, Pa.

1. "Baugh's Bone Meal, Warranted Pure."
2. "Baugh's Pure Dissolved Animal Bone."
3. "Export Bone with Potash."
4. "Baugh's Animal Bone and Potash—Compound for all Crops."
5. "The Twenty-five Dollar Phosphate."
6. "Baugh's Double Eagle Phosphate."
7. "Baugh's General Crop Grower—For all Crops."
8. "Baugh's Soluble Alkaline Super-Phosphate."
9. "Baugh's Wheat Fertilizer—For Wheat and Grass."
10. "Baugh's Potato Fertilizer."
11. "Baugh's Corn Fertilizer—For Sugar Corn and Garden Truck."
12. "The Wrapper Leaf Brand—A Special Manure for Seed Leaf Tobacco."
13. "Baugh's Special Potato Manure."
14. "Baugh's High Grade Acid Phosphate."
15. "Baugh's Ammoniated Soluble Alkaline."

BAUGHMAN, WILLIAM F., Rinely, Pa.

1. "P. & T. Special."
2. "Ammoniated Bone Phosphate."
3. "Harvest Queen Phosphate."

BAXTER, H. V., Chester, Pa.

1. "Pure Ground Bone."
2. "IXL Phosphate."

BERG COMPANY, THE, Port Richmond, Philadelphia, Pa.

1. "Berg's Special Potato Guano."
2. "Berg's Lymph Guano for all Crops."
3. "Berg's $35.00 Potato Manure."
4. "Berg's Standard Bone Manure."
5. "Berg's Pure Dissolved Bone and Potash."
6. "Berg's Pure Raw Bone Fine."
7. "Berg's Special $25.00 Bone Manure."
8. "Berg's Truckers' Jay Guano."

BERGER BROTHERS, Easton, Pa.

1. "Berger Bros. H. G. Acid Phosphate."
2. "Peerless."

BIRELY, A. D. & SONS, Ladiesburg, Md.

1. "Ammoniated Bone Phosphate."
2. "Special Mixture, Wheat and Grass."
3. "Dissolved Animal Bone and Potash."

3. "Wheat and Grass."
4. "Lehigh Super-Phosphate."
5. "Potato and Truck."

BLAKER, A. H., & CO., Fox Chase, Philadelphia, Pa.

1. "Blaker's Acid Phosphate."
2. "Blaker's Special for General Use."
3. "Blaker's Special for Potatoes."
4. "Blaker's Ground Bone."

BLOCHER, D., & CO., Gettysburg, Pa.

1. "Dissolved Raw Bone and Potash."
2. "High Grade Super-Phosphate of Bone."
3. "Ammoniated Soluble Bone Phosphate."
4. "Alkaline Bone."
5. "Dissolved Bone Phosphate."

BONDAY, JAMES, JR., & CO., No. 302 Merchants' Bank Building, Baltimore, Md.

1. "Sulphate of Potash."
2. "Muriate of Potash."
3. "German Kainit—Old Reliable Brand."

BOWKER FERTILIZER COMPANY, THE, No. 43 Chatham Street, Boston, Mass.

1. "Stockbridge Potato and Vegetable Manure."
2. "Bowker's Potash or Staple Phosphate."
3. "Bowker's Sure Crop Phosphate."
4. "Bowker's Ammoniated O. I. O."
5. "Bowker's Super-Phosphate and Potash."
6. "Bowker's Apex Phosphate."
7. "Bowker's Dissolved Bone Phosphate."
8. "Bowker's 6 Per Cent. Potato Fertilizer."
9. "Bowker's Potash Bone."
10. "Bowker's Empire State Bone Phosphate."
11. "Bowker's Hill and Drill Phosphate."
12. "Bowker's Farm and Garden Phosphate."
13. "Bowker's Wheat Grower."
14. "Bowker's Market Garden."
15. "Bone Meal."

BRADLEY & GREEN FERTILIZER CO., Ninth Street and Girard Avenue, Philadelphia, Pa.

1. "Potato Guano No. 1."
2. "Harvest Home."
3. "High Grade Acid Phosphate."
4. "Popular Phosphate—Special for Wheat."
5. "Standard Bone Phosphate—For Corn, Wheat and Peas."
6. "Market Garden."
7. "Seven Per Cent. Ammoniated Guano."

BRILLINGER, HORACE, Emigsville, Pa.

1. "Brillinger's Special Wheat, Corn and Grass Mixture
2. "Standard High Grade Phosphate."

BRODBECK, S. M., Brodbecks, Pa.

1. "Standard."
2. "Reliable."
3. "Alkaline."
4. "Ruth Dissolved Bone."

BROMFIELD & FOSTER, Colora, Md.

1. "Potato Phosphate."
2. "B. F. Ammoniated Bone."

BROWN, J, W., Tilden, York County, Pa.

1. "No. 7. Compound Fertilizer."

BRUBACHER, ELIAS S., Millbach, Pa.

1. "Wheat and Grass Special."

BUCYRUS FERTILIZER CO., THE, Bucyrus, O.

1. "Superior Pure Ground Bone."
2. "Bucyrus Bone Meal."
3. "Bucyrus Guano."
4. "Buckeye Wheat Grower."
5. "Potter's Standard Phosphate."
6. "Natural Plant Food."
7. "Dissolved Bone."
8. "Acid Phosphate."

CAMBRIA FERTILIZER COMPANY, Johnstown, Pa.

1. "Pure Fine Ground Bone Dust."
2. "Lion Ammoniated Bone Phosphate."
3. "Standard Phosphate."
4. "Corn and Potato Manure."
5. "B. & B. Phosphate."

CARROLL, G. & W. H., Plymouth Meeting, Pa.

1. "C. Prepared Lime and Potash"

CHICAGO FERTILIZER CO., THE, Security Building, Chicago, Ill.

1. "Mt. Pleasant Phosphate."
2. "No. 1 Acid Phosphate."
3. "Bone, Blood and Potash."
4. "Potash Special."
5. "Corn and Wheat Special."

CINCINNATI PHOSPHATE CO., THE, Cincinnati, O.

1. "Capitol Wheat Grower."
2. "Capitol Grain and Grass Grower."
3. "Capitol Dissolved Bone and Potash."
4. "Capitol Super-Phosphate."
5. "Capitol Tobacco Food."
6. "Capitol Ground Bone."

COE COMPANY, E. FRANK, No. 133 Front Street, New York, N. Y.

1. "High Grade Soluble Bone."
2. "XXV Phosphate. (Ammoniated Bone.)"
3. "Prize Brand Grain Fertilizer."
4. "Special Dissolved—Bone and Potash."
5. "High Grade Acid Phosphate."
6. "Pennsylvania Grain Special."
7. "Columbian Corn Fertilizer."
8. "Columbian Potato Fertilizer."
9. "XXX Acid Phosphate."

COPE, HENRY, & COMPANY, Lincoln University, Pa.

1. "Acid Phosphate."
2. "Soluble Bone and Potash."
3. "Ammoniated Bone Phosphate."
4. "Pure Bone Phosphate."
5. "Potato and Corn Phosphate."
6. "Dead Shot Phosphate."
7. "Pure Ground Bone."
8. "Queen of Elk Valley."
9. "Wheat Grower and Complete Manure."
10. "High Grade Soluble Bone and Potash."
11. "Pure Steamed Bone."

COPE, JOSIAH & COMPANY, Lincoln University, Pa.

1. "Pure Bone Phosphate."
2. "Try Me Bone Phosphate."
3. "Ammoniated Bone Phosphate."
4. "Wheat and Grass Special."
5. "Potato and Tobacco Phosphate."
6. "Acidulated Phosphate."
7. "Soluble Bone and Potash."
8. "Ground Steamed Bone."
9. "Ground Raw Bone."
10. "High-Grade Soluble Bone and Potash."

CRANSTON COMPANY, J. A., Wilmington, Del.

1. "W. B. Raw Bone Super-Phosphate."
2. "Pennsylvania Super-Phosphate."
3. "Horse Shoe Soluble Bone."
3. "Horse-Shoe Soluble Bone."

DARON, E., Dover, Pa.

1. "Daron's Harvest King Bone Phosphate."

DICKEY, J. SCOTT, No. 630 Prince Street, Lancaster, Pa.

1. "Dickey's Pulverized Tobacco Stem Fertilizer.

DOWNWARD & COMPANY, JAMES G., Coatesville, Pa.

1. "Ammoniated Bone Phosphate."
2. "Soluble Bone and Potash."
3. "Wheat and Grass Fertilizer."
4. "Acid Phosphate Rock."
5. "Royal Bone Phosphate."
6. "Special Potato Phosphate."
7. "Special Corn Manure."
8. "Pure Ground Bone."
9. "Pioneer Raw Bone Phosphate."
10. "Special Asparagus Mixture."

DUNGAN, WALLACE, Doylestown, Pa.

1. "Pebel Hill Home Made Animal Bone Mixture."
2. "Bone Flour."

EASTERN CHEMICAL COMPANY, No. 620 Atlantic Avenue, Boston, Mass

1. "Imperial Liquid Plant Food."

EBY, AMOS, Lehman Place, Pa.

1. "Pequea Bone."
2. "Pequea Economy."
3. "Pequea Ammoniated."
4. "Pequea Bone for Potatoes."
5. "Farmers' Mixture."

EUREKA FERTILIZER COMPANY, Perryville, Md.

1. "Farmers' Favorite Bone Phosphate."
2. "Standard Bone Phosphate."
3. "Grain and Grass Mixture."
4. "Corn and Potato Special."
5. "P. & P. Super-Phosphate."
6. "Potato and Vegetable Fertilizer."
7. "Imperial Bone Phosphate."
8. "Fish, Rock and Potash."
9. "Alkaline Bone and Potash."
10. "Ground Bone."
11. "Eureka Complete Fertilizer."
12. "Wrapper Leaf for Tobacco."

EWING, WASHINGTON, Landenberg, Pa.

1. "Pure Raw Bone."
2. "Eclipse Raw Bone Phosphate."
3. "Waste Land Potato Phosphate."

FAIRLAMB, R. C., & SONS, Brandywine Summit, Pa.

1. "Potato Special."
2. "Corn Special."
3. "Wheat and Grass Special."

FARMERS' FERTILIZER COMPANY, Westminster, Md.

1. "No. 3 Bone Phosphate."
2. "XX Bone Phosphate."
3. "Carroll Bone Phosphate."
4. "P. A. & P. Phosphate."
5. "Acid Phosphate."

FARMER, W. S., & CO., No. 21 S. Gay Street, Baltimore, Md.

1. "Standard Phosphate."
2. "Harvest Queen Phosphate."
3. "Clyde Brand Phosphate."
4. "B. & P. Phosphate."
5. "Dissolved S. C. Bone."

FOGLEMAN, W. H., Williamsport, Pa.

1. "Pure Bone and Potash."

FRETZ, MAHLON, Sellersville, Pa.

1. "Fretz's Standard Bone Phosphate."

FULTON, JAMES, & SONS CO., Stewartstown, Penna.

1. "Fulton's Corn and Wheat Fertilizer."

GAWTHROP, JOSEPH R., Kennett Square, Pa.

1. "Fine Ground Raw Bone Meal."
2. "Champion Bone Fertilizer for Wheat and Grass."
3. "Complete Ammoniated Bone Phos. for Corn, Oats, Potatoes and Wheat."
4. "Acid Phosphate Rock."

GLICK, I. N., R. F. D. No. 6, Lancaster, Pa.

1. "Up to Date Grain and Grass Grower."

GRIFFITH & BOYD, No. 9 S. Gay Street, Baltimore, Md.

1. "Cereal Bone Plant Food."
2. "Valley Fertilizer."
3. "Peerless Fertilizer."
4. "High Grade Acid Phosphate."
5. "Harvest Queen Phosphate."
6. "XX Potash Manure."
7. "Original Super-Phosphate."
8. "Farmers' Potato Manure."
9. "Ammoniated Bone Phosphate."
10. "Farmers' Improved Phosphate."
11. "Double Strength Tobacco Grower."
12. "Spring Crop Grower."
13. "Pure Fine Ground Bone Meal."
14. "Fish, Bone and Potash."
15. "Special Grain Grower."
16. "Royal Potash Guano."
17. "Stable Manure Substitute."

GROVE, A. M., & CO., Muddy Creek Forks, Pa.

1. "A. M. G. & Co's Standard Bone Phosphate."

HAGER, H. F., Quakertown, Pa.

1. "Hager's Ammoniated Super-Phosphate."
2. "Panic Phosphate."
3. "Farmers' Favorite Phosphate."

HANOVER FERTILIZER COMPANY, N. E. Cor. Gay and Lombard Streets, Baltimore, Md.

1. "Dissolved S. C. Rock."
2. "Royal Bone and Potash."
3. "Farmers' Crop Winner."
4. "Blood and Bone Compound."
5. "Excelsior Combine."
6. "Klondyke Special."
7. "Pure Bone Meal."
8. "High Grade Bone Potash."
9. "Dissolved Raw Bone."

HARDY PACKING COMPANY, THE, No. 189 Madison Street, Chicago, Ill.

1. "Hardy's Crop Producer."
2. "Hardy's Tankage, Bone and Potash."
3. "Hardy's Potash Fertilizer."
4. "Hardy's Phosphate and Potash."

HARTRANFT, FRANK, Coatesville, Pa.

1. "Ground Bone."
2. "Coon Bone Phosphate."
3. "Ammoniated Bone Phosphate."
4. "Potato Phosphate."
5. "Special Phosphate."
6. "Acid Phosphate."

HASTINGS, WILLIAM S., & SON., Atglen, Pa.

1. "Clear Acid Phosphate."
2. "Atglen Corn and Potato Guano."
3. "Grain and Grass Special."
4. "Soluble Bone and Potash."
5. "Octararo No. 1 Bone Phosphate."

HESS, S. M., & BRO., S. E. Cor. Fourth and Chestnut Streets, Philadelphia, Pa.

1. "Ammoniated Bone Super-Phosphate."
2. "Keystone Bone Phosphate."
3. "Wheat and Grass Manure."
4. "Emperor Phosphate."
5. "Potato and Truck Manure."
6. "High Grade Acid Phosphate."
7. "Ground Bone."
8. "Special Compound."
9. "Special Corn Manure."
10. "Special Potato Manure."
11. "Soluble Bone."

12. "Soluble Bone and Potash."
13. "Tobacco Manure."
14. "Fish and Potash Manure."
15. "The Scientific Manure."

HOFFMAN, P., & BRO., Raubsville, Pa.

1. "Potato Phosphate."
2. "King Phosphate."

HEWETT FERTILIZER COMPANY, THE, Scranton, Pa.

1. "Pure Ground Bone."

HUBBARD & COMPANY, M. P., & CO., No. 612 Equitable Building, Baltimore, Md.

1. "Hubbard's Bermuda Guano."
2. "Celebrated Dissolved Bone Phosphate for General Use."
3. "Farmers' Acme."
4. "Farmers' Old Economy."
5. "High Grade Soluble Bone and Potash."
6. "Hubbard's Excelsior Bone Phosphate."
7. "Pennsylvania Special Potato Grower."
8. "H. S. Soluble S. C. Phosphate."

HUBBARD FERTILIZER COMPANY, THE, No. 708 Merchants' Bank Building, Baltimore, Md.

1. "Hubbard's Standard Bone Super-Phosphate."
2. "Hubbard's Royal Ensign—For Early Market Vegetables."
3. "Hubbard's Farmers' IXL Super-Phosphate."
4. "Hubbard's Wheat Grower's Jewel."
5. "Hubbard's Oriental Phosphate."
6. "Hubbard's Columbia Gem Phosphate."
7. "Hubbard's Soluble Bone and Potash."
8. "Hubbard's High Grade Soluble Tennessee Phosphate."
9. "Hubbard's Trucker's 7 Per Cent. Royal Seal Compound."

INDEX COMPANY, THE, No. 426 N. Third Street, Philadelphia, Pa.

1. "Radix Fertilizer."
2. "Index Bone Phosphate."
3. "Index Ground Bone."
4. "Index Bone Meal."
5. "Index Bone Flour."
6. "Spiro Bone Meal."
7. "Michell's Bone Phosphate."
8. "Michell's Pure Bone Meal."

INTERNATIONAL SEED COMPANY, Rochester, N. Y.

1. "International Grain and Grass Fertilizer."
2. "International Potato and Truck Manure."
3. "International A. L. Special Manure."

JARECKI COMMERCIAL COMPANY, Sandusky, Ohio.

1. "Lake Erie Fish Guano."
2. "Fish and Potash Grain Special."
3. "Number One Fish Guano."
4. "C. O. D. Phosphate."
5. "Pure Ground Bone."
6. "St. Bernard Phosphate."
7. "Dissolved Bone Black Wheat Special."
8. "Fish and Potash Potato and Tobacco Food."
9. "O. K. Fertilizer."
10. "Dissolved Bone with Potash."

JONES, W. C., SONS, Doe Run, Pa.

1. "High Grade Dissolved S. C. Rock."
2. "Dissolved Bone Phosphate."

KENDERDINE, T. S., & SONS, Newtown, Pa.

1. "Kenderdine's Potato Phosphate."
2. "Kenderdine's Bone Phosphate."
3. "Kenderdine's Ammoniated Phosphate."

KUHNS, DAVID, Lehighton, Pa.

1. "Pure Ground Bone Meal."

KURTZ & STUNKARD, Green Bank, Pa.

1. "Conestoga Regulator."
2. "Conestoga Fancy."

LACKAWANNA FERTILIZER & CHEMICAL CO., Moosic, Pa.

1. "Moosic Phosphate."
2. "Special Manure."
3. "Our Admiral Dewey."
4. "Bone Super-Phosphate."
5. "Alkaline Bone."
6. "Warranted Pure Ground Bone."
7. "Acid Phosphate."
8. "Big Yield."
9. "Wyoming Guano."
10. "Kali Chief."

LANCASTER CHEMICAL COMPANY, Lancaster, Pa.

1. "Tobacco and Vegetable."
2. "Dewey Brand."
3. "Pure Dissolved Animal Bone and Potash."
4. "Rising Sun Animal Bone."
5. "Pure Dissolved Animal Bone."
6. "Flag Brand."
7. "Hard Times Fertilizer."
8. "Economist."
9. "Acid Phosphate."
10. "Keystone Brand."
11. "Alkaline Bone."
12. "Bone Meal."
13. "Special Potato Manure."

LEBERNIGHT, B. F., Red Lion, Pa.

1. "Lebernight's Standard Ammoniated Bone Phosphate."

LEIB, J. C., & Co., Stewartstown, Pa.

1. "Gemmills Mixture."

LETHERBURY, D. A., Chester, Pa.

1. "Chester Brand Bone Phosphate."

LEVAN, DANIEL, Lebanon, Pa.

1. "Wheat and Grass Special."
2. "Keystone Bone Fertilizer."
3. "Bone and Potash Compound."

LISTER'S AGRICULTURAL CHEMICAL WORKS, Newark, N. J.

1. "Lister's Animal Bone and Potash."
2. "Lister's Animal Bone and Potash No. 2."
3. "Lister's Corn and Potato Fertilizer."
4. "Lister's Success Fertilizer."
5. "Lister's Standard Pure Bone Super-Phosphate."
6. "Lister's Potato Fertilizer No. 2."
7. "Lister's Special Wheat Fertilizer."
8. "Lister's Special 10 Per Cent. Potato Fertilizer."
9. "Lister's "G" Brand."
10. "Lister's Special Crop Producer."
11. "Lister's Ammoniated Dissolved Bone Phosphate."
12. "Lister's Harvest Queen Phosphate."
13. "Lister's Potato Manure."
14. "Lister's U. S. Super-Phosphate."
15. "Lister's Alkaline Bone."
16. "Lister's 3—6—10 for Potatoes."
17. "Lister's Celebrated Ground Bone Acidulated."
18. "Lister's Pure Raw Bone Meal."

McCALMONT & CO., Bellefonte, Pa.

1. "McCalmont & Co's. $25.00 Ammoniated Bone Super-Phosphate."

MAPES FORMULA AND PERUVIAN GUANO CO., No. 143 Liberty Street, New York, N. Y.

1. "Mapes Potato Manure."
2. "Mapes Tobacco Starter Improved."
3. "Mapes Tobacco Manure (Wrapper Brand)."
4. "Mapes Fruit and Vine Manure."
5. "Mapes Vegetable Manure or Complete Manure for Light Soils."
6. "Mapes Average Soil Compound Manure."
7. "Mapes Economical Potato Manure."
8. "Mapes Cauliflower and Cabbage."
9. "Mapes Corn Manure."
10. "Mapes Complete Manure, "A" Brand."

11. "Mapes Complete Manure for General Use."
12. "Mapes Ammoniated Dissolved Bone with Potash."
13. "Mapes Cereal Brand."
14. "Mapes Grain Brand."
15. "Mapes General Crop Brand."
16. "Mapes Top Dresser Improved—Half Strength."

MARKEL, NOAH, Seitzland, Pa.

1. "Markel's Ammoniated Bone Phosphate."
2. "Markel's Potato Grower."
3. "Markel's Electric Phosphate."

MARTIN CO., THE D. B., 1204 Land Title Building, Philadelphia, Pa.

1. "Special Dissolved Bone and Potash Compound."
2. "Claremont Dissolved Bone and Potash."
3. "Pure Dissolved Animal Bone."
4. "Ground Bone."

MEHRING, FREDERICK, Bruceville, Pa.

1. "Dissolved Raw Bone."
2. "Twenty-six Dollar Phosphate."
3. "General Crop Grower."
4. "Acid Phosphate."

MILLER FERTILIZER COMPANY, No. 411 E. Pratt Street, Baltimore, Md.

1. "Ammoniated Dissolved Bone."
2. "Harvest Queen."
3. "Special Potato."
4. "Hustler Phosphate."
5. "W. G. Phosphate."
6. "Standard Phosphate."
7. "Clinch Phosphate."
8. "South Carolina Rock."

MORRIS, NELSON & CO., Union Stock Yards, Chicago, Ill.

1. "Big Two. Pure Bone Meal."
2. "Big Three. Bone Phosphate."
3. "Big Four. Bone Phosphate."
4. "Big Five. Bone Phosphate."

MOWREY LATSHAW HARDWARE CO., THE, Spring City, Pa.

1. "Red Clover Brand."

NASSAU FERTILIZER CO., No. 5 Beaver Street, New York, N. Y.

1. "Soluble Bone and Potash."
2. "Grass and Grain Fertilizer."
3. "Potash and Phosphate."
4. "Wheat and Grass Grower."
5. "General Favorite."

6. "Nassau Practical."
7. "Common Sense Fertilizer."
8. "The Harvester."
9. "Plow Brand."
10. "Raw Ground Bone."
11. "Acid Phosphate."
12. "Muriate of Potash."

NELLER, AUG., & CO., Stewartstown, Pa.

1. "Prolific Phosphate."
2. "Special Compound Phosphate."

NEW JERSEY AGRICULTURAL CHEMICAL CO., Newark, N. J.

1. "Potato Manure."
2. "Champion."
3. "Russell's Ground Bone."
4. "Russell's Ammoniated Dissolved Bone Phosphate."
5. "Russell's Special Corn Manure."
6. "Harvest Queen."

NEWPORT, WILLIAM C., CO., Willow Grove, Pa.

1. "Evan's Brand Potato and Tobacco Manure."
2. "Rectified Phosphate."
3. "Gilt Edge Potato Manure."
4. "Fish, Bone and Potash."
5. "Farmers' Ammoniated Bone Phosphate."
6. "Grain and Grass Special."
7. "Soluble Bone and Potash."
8. "Acid Phosphate."
9. "Bone Meal."
10. "Newport's Special Compound for Wheat and Grass."
11. "No. 1 Bone Phosphate."
12. "Truckers' Joy."
13. "Potato, Tobacco and Truck Guano."

OBER, G., & SONS, No. 33 S. Gay Street, Baltimore, Md.

1. "Ober's Special Plant Food."
2. "Ober's Farmers' Mixture."
3. "Ober's Dissolved Bone Phosphate and Potash."
4. "Ober's Dissolved Bone Phosphate."
5. "Ober's Independent Ammoniated Super-Phosphate."

OHIO FARMERS' FERTILIZER CO., Columbus, O.

1. "Acid Phosphate."
2. "Superior Phosphate."
3. "Soluble Bone and Potash."
4. "General Crop and Fish Guano."
5. "Corn, Oats and Wheat Fish Guano."
6. "Wheat Maker and Seeding Down."
7. "Fine Ground Bone Meal."
8. "Ammoniated Bone and Potash."

OSCEOLA FERTILIZER COMPANY, Osceola Mills, Pa.

1. "Pie Brand Ground Bone."
2. "Ideal Manure."

OWENS, W. C., Philipsburg, Pa.

1. "Owens' Ammoniated Phosphate."

PATAPSCO GUANO COMPANY, P. O. Box 213, Baltimore, Md.

1. "Patapsco Pure Ground Bone."
2. "Patapsco Soluble Bone and Potash."
3. "Patapsco Fish Guano."
4. "Patapsco Special Wheat Compound."
5. "Sea Gull Guano."
6. "Coon Brand Guano."
7. "Baltimore Soluble Phosphate."
8. "Patapsco Dissolved S. C. Bone."
9. "Grange Mixture."
10. "Patapsco Grain and Grass Producer."
11. "Patapsco Early Trucker."
12. "Patapsco Tobacco and Potato Fertilizer."
13. "Patapsco Corn and Tomato Fertilizer."
14. "Patapsco High Grade Bone and Potash."
15. "Battle Ax Phosphate."

PATTERSON FERTILIZER CO., No. 4025 Market Street, Philadelphia, Pa.

1. "Patterson's Mineral Compound."

PENNSYLVANIA AMMONIA AND FERTILIZER CO., LIM., Harrisburg, Pa.

1. "Potato, Vegetable and Tobacco."
2. "Dauphin Brand."
3. "Pure Ground Bone."
4. "Capital Bone Super-Phosphate."
5. "Royal Mixture."
6. "Soluble Bone and Potash."
7. "General Crop Grower."

PERKINS, A. W., & CO., Rutland, Vt.

1. "Plantene."

PERKINS, J. DOUGLASS, Coatesville, Pa.

1. "Perkins' Monarch Phosphate."
2. "Perkins' Ammoniated Bone Phosphate."
3. "Perkins' Special Bone Manure."
4. "Perkins' Globe Phosphate."
5. "Perkins' Pure Bone Meal."
6. "Perkins' Acidulated Phosphate."

PIEDMONT-MT. AIRY GUANO CO., THE, No. 109 Commerce Street, Baltimore, Md.

1. "Levering's Standard."
2. "Piedmont High Grade S. C. Bone."
3. "Piedmont Royal Ammoniated Bone and Potash."
4. "Piedmont Soluble Bone and Potash."
5. "Piedmont Pure Raw Bone Mixture."
6. "Levering's Harvest Queen."
7. "Levering's IXL Phosphate."
8. "Diamond (S) Soluble Bone."
9. "Piedmont Pennsylvania Potato Producer."
10. "Piedmont Special Potato Goods."
11. "Levering's Ammoniated Bone."

PITTSBURG PROVISION CO., Pittsburg, Pa.

1. "No. 1 Pure Raw Bone Meal."
2. "Pure Raw Bone Meal."
3. "Crescent Butchers' Ground Bone."
4. "Pure Bone with Potash."
5. "Corn and Potato Fertilizer."
6. "Keystone Fertilizer."
7. "Guano Fertilizer."
8. "Acid Phosphate."
9. "Phosphate and Potash."

POLLOCK, R. H., No. 51 S. Gay Street, Baltimore, Md.

1. "Dissolved S. C. Bone."
2. "Victor Bone Phosphate."
3. "Superior Corn and Tomato Fertilizer."
4. "Owl Brand Guano."
5. "Special Potato and Tobacco Fertilizer."
6. "Special Wheat Grower."
7. "Ammoniated Bone Phosphate."
8. "Soft Ground Bone."
9. "Dissolved Animal Bone."
10. "Grain and Vegetable Compound."

PUGH & LYON, Oxford, Pa.

1. "Ground Raw Bone."
2. "Bone Phosphate."

RAMSBURG FERTILIZER COMPANY, Frederick, Md.

1. "Excelsior Plant Food."
2. "Old Virginia Compound."
3. "Ammoniated Bone Phosphate."
4. "Alkaline Phosphate."
5. "Dissolved Bone Super-Phosphate."
6. "Ramsburg's Queen."

RASIN-MONUMENTAL COMPANY, No. 300 Water Street, Baltimore, Md.

1. "Rasin's Empire Guano."
2. "Rasin's Ammoniated Super-Phosphate."
3. "Rasin's Bone and Potash Fertilizer."
4. "Rasin's Acid Phosphate."
5. "Rasin's IXL Fertilizer."
6. "Special Formula for Corn and Buckwheat."
7. "Seawall Special."
8. "Rasin's Ammoniated Alkaline Phosphate."
9. "Rasin's Wm. Penn Crop Grower."
10. "Monumental Soluble Bone and Potash."
11. "Monumental Acid Phosphate."
12. "Arundel Complete."

RAUH, E., & SONS., No. 419 S. Penn Street, Indianapolis, Ind.

1. "Dissolved Bone and Potash."
2. "Soluble Bone."
3. "Ideal Phosphate."
4. "Fish Guano."
5. "Our Special."

READING CHEMICAL AND FERTILIZING CO., LIM., Reading, Pa.

1. "Potato and Vegetable Brand."
2. "Neversink Brand."
3. "A. A. Brand."
4. "Mt. Penn Brand."
5. "Reading Star Brand."

REESE, JACOB, No. 400 Chestnut Street, Philadelphia, Pa.

1. "Odorless Slag Phosphate."

REICHARD, J. G. & BRO., Allentown, Pa.

1. "The Lehigh Potato Manure."
2. "Surface Phosphate."
3. "Little Giant Phosphate."

RICE, HAMPTON, Lumberville, Pa.

1. "W. Kenderdine's A. A. Phosphate."
2. "W. Kenderdine's A. B. Phosphate."

RITTER & WARNER, Indiana, Pa.

1. "Mare Fertilizer."

RIVERSIDE ACID PHOSPHATE, Warren, Pa.

1. "Harvest Moon Phosphate."
2. "Rich-acre Phosphate."
3. "Old Gold Phosphate."
4. "Phosphate and Potash."

SALE, GEORGE F. (Sandiford), Philadelphia, Pa.

1. "Geo. F. Sale's Special Manure for all Crops."

SCHAAL-SHELDON FERTILIZER CO., Erie, Pa.

1. "Sheldon's Empire."
2. "Sheldon's Farmers' Favorite."
3. "Schaal's Standard."
4. "Sheldon's Grass, Grain and Potato."
5. "Schaal's Corn and Potato."
6. "Sheldon's Guano."
7. "Pure Bone Meal."
8. "Dissolved Bone and Extra Potash."
9. "Dissolved Bone and Potash."
10. "Dissolved Bone."

SCHMUCHER, A. B., Hazleton, Pa.

1. "Hazel Brand."

SCIENTIFIC FERTILIZER CO., THE, Pittsburg, Pa.

1. "Scientific Corn and Grain Fertilizer."
2. "Scientific Economy."
3. "Scientific Bone, Meat and Potash Fertilizer."
4. "Scientific Potato Fertilizer."
5. "Scientific Dissolved Bone Fertilizer."
6. "Scientific Phosphate and Potash Fertilizer."
7. "Bone and Meat."
8. "Pure Raw Bone Meal."
9. "High Grade Acid Phosphate."
10. "Scientific Wheat and Clover Fertilizer."
11. "Scientific Grain Grower."
12. "Scientific Bone and Potash Fertilizer."
13. "Patrons' Special."

SCOTT FERTILIZER CO., THE, Elkton, Pa.

1. "Sure Growth Super-Phosphate."
2. "Standard Phosphate."
3. "Elk Head Super-Phosphate."
4. "Corn and Oats Grower."
5. "Tip Top Soluble Bone."
6. "Scott's Potato Grower."
7. "Potato, Truck and Tobacco Grower."
8. "Wheat and Grass Grower."
9. "Tip Top and Potash."
10. "Sure Growth Compound."
11. "Fritch's Grain Special."
12. "Grain Special."

SHENANDOAH FERTILIZER COMPANY, Shenandoah, Pa.

1. "Standard Potash Brand."
2. "Ringtown Clover."
3. "Gold Eagle."
4. "N. & S. Complete Clover."
5. "Special Wheat."
6. "Pure Ground Bone."

SHOEMAKER, M. L., & CO., Cor. Delaware Avenue and Venango Streets, Philadelphia, Pa."

1. "Swift Sure Phosphate for General Use."
2. "Swift Sure Phosphate for Potatoes."
3. "Swift Sure Phosphate for Tobacco."
4. "Swift Sure Special 10 Per Cent. Potato Fertilizer No. 1."
5. "Swift Sure Special 10 Per Cent. Potato Fertilizer No. 2."
6. "Swift Sure Guano for Tomatoes, Truck and Corn."
7. "Swift Sure Guano for Fall Trade."
8. "Swift Sure New Jersey Special for Oats."
9. "Swift Sure New Jersey Special for Wheat and Clover."
10. "Swift Sure Bone Meal."
11. "Swift Sure Dissolved Bone."
12. "Good Enough Phosphate."
13. "Echo Phosphate."
14. "Twenty-three Dollar Phosphate."
15. "Dissolved S. C. Rock."
16. "Pure Raw Bone Meal."
17. "Dissolved Bone and Potash."

SICKLER, CHAS. A., & BRO., Wilkes-Barre, Pa.

1. "Special Manure for Potatoes and Vegetables.'
2. "Vegetable and Vine Fertilizer."
3. "Empire Phosphate."
4. "King Phosphate."
5. "Monarch Phosphate."
6. "Pure Ground Bone."
7. "Graves Potato and Tobacco Manure."
8. "Peerless Phosphate."
9. "Empire Corn Fertilizer."

SIMON, T. A., Maud P. O., Pa.

1. "Truck and Corn."
2. "Potato Grade."
3. "General Use."

SLAGLE, E. A., Paxinos, Pa.

1. "Xtra Bone Phosphate."

SMYSER, H. H., York, Pa.

1. "Chicago Soluble Bone."
2. "Chicago Crop Grower."
3. "Chicago Bone and Tankage."
4. "Chicago Bone and Potash."

SOUTHERN FERTILIZER COMPANY, York, Pa.

1. "Ox Brand Ammoniated Dissolved Bone."
2. "Ox Brand Special Potato Grower."
3. "Ox Brand General Crop Grower."
4. "Ox Brand Farmers' Choice Brand."

5. "Ox Brand Dissolved Bone Phosphate."
6. "Ox Brand Soluble Bone and Potash."
7. "Ox Brand Queen of the Harvest."
8. "Ox Brand Pure Ground Bone."
9. "Bone and Potash Mixture."
10. "Royal Wheat and Grass Grower."
11. "Farmer's Mixture."

STERNER, E. H., Codorus, Pa.

1. "Sterner's Dissolved Bone Phosphate."

STRAINING, JOHN E., No. 1752 N. Cameron Street, Harrisburg, Pa.

1. "Bone and Meat Fertilizer."

SWIFT & COMPANY, Union Stock Yards, Chicago, Ill.

1. "Swift's Super-Phosphate."
2. "Swift's Complete Fertilizer."
3. "Swift's Ammoniated Bone."
4. "Swift's Pure Raw Bone Meal."
5. "Swift's Bone Meal."
6. "Swift's Diamond (S) Phophate."
7. "Swift's Onion and Potato Special."
8. "Swift's Special Bone Meal."
9. "Swift's Champion Wheat Grower."
10. "Swift's Champion Corn Grower."
11. "Swift's Phosphate and Potash."
12. "Swift's Pure Acid Phosphate."
13. "Swift's Vegetable Grower."
14. "Swift's Sugar Beet Grower."
15. "Swift's Special Phosphate and Potash."

TAYLOR PROVISION COMPANY, THE, Trenton, N. J.

1. "Special Potato."
2. "Corn and Truck."
3. "Ammoniated Dissolved Bone."

TEMPIN, J. M., Honeybrook, Pa.

1. "No. 3. Farmers' Complete Fertilizer."
2. "No. 4. Atlas Brand."
3. "No. 5. High Grade Acid Phosphate."
4. "No. 8. High Grade Potash Manure."
5. "No. 16. Cereal Fertilizer."

THOMAS, D. A., Hagerstown, Md.

1. "Thomas' Bone Mixture."
2. "Thomas' Mixture."
3. "Dissolved Bone Phosphate."

THOMAS, HAINES & CO., Malvern, Pa.

1. "New Century Crop Grower."

THOMAS, JAMES, Williamsport, Pa.

1. "Thomas' High Grade Bone Super-Phosphate."
2. "Thomas' Klondyke Brand."
3. "Thomas' High Grade Potato and Tobacco Manure."
4. "Thomas' Special Compound for Wheat, Oats, Corn and Grass."
5. "Thomas' Standard Bone Phosphate."
6. "Thomas' Florida Bone Phosphate."
7. "Thomas' Dissolved Florida Bone and Potash Phosphate."

THOMAS, I. P., & SONS COMPANY, No. 2 S. Delaware Avenue, Philadelphia, Pa.

1. "S. C. Phosphate."
2. "Farmers' Choice Bone Phosphate."
3. "Normal Bone Phosphate."
4. "Improved Super-Phosphate."
5. "Special Corn Fertilizer."
6. "Alkaline Bone."
7. "Special Alkaline Bone."
8. "Dissolved Phosphate."
9. "Tip Top Raw Bone Super-Phosphate."
10. "Pure Ground Animal Bone."
11. "Potato Fertilizer."
12. "Champion Bone Phosphate."
13. "Superior Super-Phosphate."
14. "Special Truckers' Fertilizer."
15. "Wheat, Corn Fertilizer."

TOMLINSON, WATSON, JR., Torresdale, Philadelphia, Pa.

1. "Tomlinson's Potato Fertilizer and Crop Feeder."
2. "Tomlinson's Ammoniated Potato Fertilizer."
3. "Tomlinson's All Crop Fertilizer."
4. "Tomlinson's Market Garden Guano."
5. "Tomlinson's Grain and Grass Fertilizer."

TRENTON BONE FERTILIZER CO., Trenton, N. J.

1. "Trenton Super-Phosphate."
2. "Trenton Corn Mixture."
3. "Trenton $32.00 Potato Manure."
4. "Trenton Potato Manure."
5. "Trenton Excelsior."
6. "Trenton Corn and Truck Fertilizer."
7. "Pure Fine Ground Bone."
8. "Trenton XX Brand Fertilizer."
9. "Trenton Special Potato Manure."

TRINLEY, JACOB, Linfield, Pa.

1. "Pure Raw Bone Meal."
2. "Pure Raw Bone Super-Phosphate."
3. "Grain and Grass Grower."
4. "Ravere Bone Phosphate."
5. "Soluble Bone and Potash."

TUSCARORA FERTILIZER COMPANY, THE, Port Royal, Pa.

1. "Ammoniated Phosphate."

TUSTIN, I. J., Phoenixville, Pa.

1. "Pickering Valley Special for Potatoes."
2. "Pickering Valley Special."
3. "Pickering Valley High Grade."

TYGERT, THE, J. E., COMPANY, No. 42 S. Delaware Avenue, Philadelphia, Pa.

1. "Bone Phosphate."
2. "Ground Bone."
3. "Soluble Bone and Potash."
4. "Potato Guano."
5. "Ammoniated Super-Phosphate."
6. "Popular Phosphate."
7. "Golden Harvest Phosphate."
8. "Acid Phosphate."

TYGERT, J. E., & SON, Philadelphia, Pa.

1. "Early Harvest Phosphate."
2. "Dissolved Bone Phosphate with Potash."

ULMER, JACOB, PACKING COMPANY, Pottsville, Pa.

1. "Ulmer's Blood, Meat and Bone Super-Phosphate."

UNIONTOWN FERTILIZER WORKS, Uniontown, Pa.

1. "Fell's Pure Ground Bone."
2. "Fell's Gold Premium Bone Phosphate."
3. "Fell's High Grade Acid Phosphate."

WAHL, EMIL, MANF'G. CO., Nos. 3970-3986 Pulaski Avenue (Nicetown), Philadelphia, Pa.

1. "Emil Wahl's Warranted Pure Philadelphia Button Bone Dust."

WALKER, STRATMAN & COMPANY, Herr's Island, Allegheny, Pa.

1. "Four Fold."
2. "Grain King."
3. "Big Bonanza."
4. "Potato Special."
5. "Meat, Blood and Bone with Potash."
6. "Help Mate."
7. "Phosphoric Acid and Potash."
8. "Bone and Meat."
9. "Pure Raw Bone Meal."
10. "Acid Phosphate."
11. "Grain Manure."
12. "Potash and Bone Phosphate."

WALKER, J. C., & SON, Gap, Pa.

1. "Pride of Pequea."
2. "Pride of Pequea, High Grade."

WALT, F. K., & CO., Supplee P. O., Pa.

1. "Flesh and Bone Phosphate."
2. "Calcine Bone Phosphate."
3. "Sure Growth Phosphate."

WHANN, W. E., William Penn P. O., Pa.

1. "Special Potato and Truck Fertilizer."
2. "Raw Bone Super-Phosphate."
3. "Fish and Potash Fertilizer."
4. "Ammoniated Phosphate."
5. "No. 2 Ammoniated Phosphate."
6. "Special Ammoniated Phosphate."
7. "Soluble Bone and Potash."
8. "Available Ammoniated Phosphate."
9. "South Carolina Phosphate."
10. "Pure Ground Raw Bone."
11. "Sweet Potato and Celery Mixture."
12. "Pure Ground Bone."

WHANN, JOHN, & SON, No. 28 S. Delaware Avenue, Philadelphia, Pa.

1. "Our Brand Raw Bone Phosphate."
2. "A. A. Acid Phosphate."
3. "J. W. & S. Special Mixture."
4. "Wheat and Grass Mixture."
5. "Reliable Ammoniated Super-Phosphate."
6. "Whann's Soluble Bone and Potash."

WINDLE, DOAN & CO., Coatesville, Pa.

1. "Ground Bone."
2. "Cook's Bone Phosphate."
3. "Ammoniated Bone Phosphate."
4. "Potato Phosphate."

WOOLDRIDGE, THE R. A., COMPANY, No. 33 S. Gay street, Baltimore, Md.

1. "Florida Acid Phosphate."
2. "German Potash Mixture."
3. "Liberty Bell Potash Mixture."
4. "Champion Giant Phosphate."
5. "Chieftain Bone Stock Phosphate."
6. "Triumph Pure Bone Phosphate."
7. "Special Potato Fertilizer."
8. "Tuckahoe Bone Meal."
9. "Buffalo Bone Stock Phosphate."
10. "Pure Raw Bone."
11. "Sweepstakes, Sure Shot, Truck Phosphate."

YORK CHEMICAL WORKS, York, Pa.

1. "Plow Brand."
2. "Standard Potash."
3. "Prosperity."
4. "Harvest Queen."

5. "New York."
6. "Half and Half."
7. "Red Cross."
8. "Black Cross."
9. "Wheat Special."
10. "Dissolved Phosphate."
11. "Dempwolf's Standard Fertilizer."
12. "Dempwolf's Corn and Oats Special."
13. "Special Tobacco."
14. "Potato and Truck Special."
15. "Pure Ground Bone."
16. "Dempwolf's Gem Fertilizer."

ZEIGLER, E. H., & CO., Stewartstown, Pa. .

1. "Bone Phosphate."
2. "Zeigler's Potato Phosphate."
3. "Zeigler's Mixture."
4. "Zeigler's Crop Grower."

ZOOK, HENRY S., Elverson, Pa.

1. "No. 5. Pride of Chester Corn, Oats and Wheat Fertilizer."
2. "No. 6. Pride of Chester Dissolved Animal Bone Phosphate."
3. "No. 7. Pride of Chester Dissolved Animal Bone Phosphate for General Use."
4. "Zook's Clear Acid Phosphate."

CROP REPORT FOR 1902.

Giving Prices of Farm Products and Live Stock, with Farm Wages and Board, in Pennsylvania, by Counties. Collected by A. L. Martin, Deputy Secretary of Agriculture.

Counties.	Cereals. Per Bushel.					Hay. Per Ton.		Live Stock.											
	Wheat.	Corn.	Oats.	Rye.	Buckwheat.	Hay, clover.	Hay, timothy.	Horses, average.	Mules, average.	Cows, average.	Lambs, average.	Ewes, average.	Steers, fat, per lb.	Steers for feeding, per lb.	Swine, shoats, per lb.	Fat hogs, per lb.	Chickens, dressed, per lb.	Chickens, live, per lb.
Adams,	$0.69	$0.53	$0.33	$0.52	$0.46	$11 50	$15 20	$114 00	$110 00	$33 00	$3 00	$3 50	$0.05	$0.04	$0.07	$0.08	$0.12	$0.09
Allegheny,	64	69	45	63	78	14 00	16 33	125 00	105 00	47 00	3 90	3 50	06	04	06	07	18	13
Armstrong,	67	63	42	58	58	10 00	13 00	93 00	95 00	37 00	3 50	3 75	05	04	06	07	15	13
Beaver,	68	67	39	58	65	11 00	13 30	108 00	100 00	31 00	3 33	3 16	06	04	06	07	17	12
Bedford,	80	68	38	66	52	11 00	13 66	83 00	....	26 00	2 50	2 83	04	....	06	05	09	07
Berks,	75	57	37	50	....	12 00	14 00	77 00	100 00	29 00	....	....	07	01	12	08	13	08
Blair,	77	65	50	68	....	11 00	15 00	80 00	60 00	32 00	....	....	05	04	08	07	16	09
Bradford,	83	71	42	61	61	9 00	11 75	94 00	....	31 00	3 25	3 25	05	03	06	06	11	09
Bucks,	72	67	38	57	56	14 75	16 75	140 00	148 00	47 00	5 50	5 00	06	01	07	09	14	11
Butler,	71	52	45	60	63	10 00	12 50	116 00	....	35 00	2 80	3 70	06	....	05	07	15	08
Cambria,	81	79	50	68	60	14 00	15 00	100 00	113 00	32 00	2 62	3 50	07	06	07	07	14	10
Cameron,	92	80	52	68	75	12 00	16 00	100 00	....	30 00	2 50	2 50	07	06	06	10	12	10
Carbon,	80	67	41	63	48	13 50	16 00	125 00	125 00	25 00	....	....	06	....	08	08	14	12
Centre,	75	57	45	55	50	9 00	11 00	105 00	110 00	35 00	3 00	3 25	05	04	05	06	09	07
Chester,	69	53	40	65	....	13 00	16 00	136 00	175 00	42 00	5 00	4 50	05	04	09	09	14	12
Clarion,	72	72	40	63	53	8 00	11 00	116 00	....	28 00	3 00	2 75	05	04	07	07	12	09
Clearfield,	85	87	45	65	55	13 50	15 00	150 00	130 00	35 00	3 50	2 75	04	03	08	08	15	11
Clinton,	76	63	40	56	50	10 00	13 00	112 00	....	35 00	....	....	05	04	06	08	13	09
Columbia,	72	68	36	54	55	11 00	13 66	113 00	125 00	31 00	4,25	4 50	05	04	06	07	12	08
Crawford,	73	70	36	57	54	6 25	9 00	90 00	63 00	30 00	3 10	3 66	04	03	06	07	12	08
Cumberland,	72	61	37	53	....	10 50	13 75	90 00	103 00	32 00	3 50	3 75	05	04	07	08	12	08
Dauphin,	73	60	40	58	....	13 00	17 00	117 00	128 00	38 00	3 00	....	05	04	06	07	10	08

CROP REPORT FOR 1902—Continued.

Counties.	Cereals. Per Bushel. Wheat.	Corn.	Oats.	Rye.	Buckwheat.	Hay. Per Ton. Hay, clover.	Hay, timothy.	Live Stock. Horses, average.	Mules, average.	Cows, average.	Lambs, average.	Ewes, average.	Steers, fat, per lb.	Steers for feeding, per lb.	Swine, shoats, per lb.	Fat hogs, per lb.	Chickens, dressed, per lb.	Chickens, live, per lb.
Delaware,	79	65	[illegible]	65	....	14 00	17 00	150 00	160 00	50 00	4 50	4 75	08	06	10	09	16	12
Elk,	1 10	55	45	70	90	....	18 00	150 00	....	....	3 50	4 25	05	....	....	08	11	....
Erie,	75	66	[illegible]	53	49	7 50	8 50	113 00	....	29 00	2 80	3 50	07	04	06	06	15	[illegible]
Fayette,	63	50	[illegible]	60	60	12 00	16 00	135 00	177 00	19 00	....	5 00	05	04	04	08	17	[illegible]
Forest,	82	47	38	74	62	11 00	14 00	116 00	90 00	30 00	2 50	3 00	04	05	04	06	12	[illegible]
Franklin,	72	61	44	54	55	9 50	12 50	116 00	125 00	32 00	3 83	5 00	06	04	07	07	13	[illegible]
Fulton,	68	60	41	60	78	10 00	12 00	85 00	75 00	29 00	2 75	3 00	04	03	06	07	16	08
Greene,	71	60	36	67	....	9 50	12 00	75 00	80 00	31 00	1 60	2 10	04	04	06	06	12	10
Huntingdon,	70	75	45	55	70	....	15 00	86 00	90 00	30 00	3 25	3 00	03	....	07	06	....	[illegible]
Indiana,	67	74	45	56	70	10 00	12 50	125 00	100 00	35 00	3 00	3 75	04	04	07	06	11	[illegible]
Jefferson,	73	70	45	63	60	9 50	13 00	105 00	100 00	30 00	2 30	2 87	04	03	06	07	[illegible]	[illegible]
Juniata,	71	57	37	57	50	8 00	12 00	105 00	108 00	25 00	3 00	[illegible] 50	06	04	05	07	11	[illegible]
Lackawanna,	79	73	50	[illegible]	50	12 00	16 00	130 00	120 00	27 00	3 00	2 75	04	05	07	08	13	[illegible]
Lancaster,	75	45	45	55	55	10 00	14 00	110 00	112 00	30 00	1 75	3 65	06	04	12	08	16	08
Lawrence,	71	57	35	53	....	12 50	12 50	100 00	100 00	37 00	3 00	3 25	05	05	06	07	15	11
Lebanon,	69	65	37	57	55	15 00	17 50	100 00	110 00	40 00	5 00	4 [illegible]	06	04	07	07	12	[illegible]
Lehigh,	74	65	44	56	65	12 00	15 00	125 00	[illegible]	40 00	6 00	5 00	05	04	07	08	12	[illegible]
Luzerne,	76	69	45	67	55	15 00	18 50	[illegible]	120 00	35 00	4 00	4 00	08	[illegible]	07	08	15	[illegible]
Lycoming,	75	70	40	50	60	10 00	13 00	150 00	175 00	35 00	3 50	3 00	06	04	06	07	13	[illegible]
McKean,	90	73	40	75	65	8 00	10 00	120 00	....	32 00	3 25	3 00	04	[illegible]	....	06	16	10
Mercer,	75	65	41	58	54	8 33	10 33	113 00	125 00	35 00	2 43	[illegible]	06	04	05	07	13	08
Mifflin,	70	61	39	60	65	11 00	13 00	107 00	[illegible]	35 00	4 00	4 00	05	04	08	07	11	10
Monroe,	77	78	44	62	63	11 00	[illegible]	108 00	125 00	29 00	3 60	3 50	....	....	[illegible]	08	10	11
Montgomery,	70	70	48	60	....	16 00	18 00	140 00	80 00	40 00	4 50	4 00	07	06	[illegible]	09	15	11
Montour,	71	55	[illegible]	57	53	9 00	12 00	80 00	80 00	30 00	2 00	2 75	[illegible]	04	[illegible]	07	15	10
Northampton,	76	70	[illegible]	64	81	12 00	16 00	123 00	140 00	38 00	[illegible]	4 25	06	[illegible]	05	08	16	12
Northumberland,	76	58	48	58	52	10 75	13 75	118 00	125 00	23 00	4 00	4 85	[illegible]	05	06	06	13	10
Perry,	70	63	[illegible]	57	48	9 25	13 25	93 00	123 00	30 00	3 25	3 67	06	04	06	07	09	09
Philadelphia,	85	75	50	67	68	10 00	8 50	88 00	100 00	28 00	4 00	3 75	05	03	06	06	11½	10

Pike,	85	75	50	67	68	10 00	8 50	88 00	100 00	28 00	4 00	3 75	05	03	06	06	12	10
Potter,	....	65	32	60	53	11 00	17 00	120 00	65 00	35 00	2 75	2 50	....	....	06	08	13	10
Schuylkill,	80	72	35	63	72	14 00	20 00	102 00	105 00	35 00	....	5 00	08	04	13	09	15	10
Snyder,	78	64	39	53	50	11 00	13 00	75 00	78 00	27 00	2 25	3 75	07	04	05	08	12	08
Somerset,	80	60	42	59	52	12 50	16 00	137 00	125 00	40 00	4 00	3 17	06	04	06	07	11	10
Sullivan,	90	60	29	60	45	10 00	10 00	105 00	....	25 00	2 00	2 25	04	04	07	07	09	07
Susquehanna,	80	75	45	65	73	10 00	12 00	109 00	50 00	20 00	3 00	2 92	05	04	06	06	12	09
Tioga,	80	60	40	55	53	8 00	12 00	85 00	....	18 00	2 75	3 75	04	03	06	06	11	07
Union,	74	58	50	50	50	9 00	12 00	73 00	63 00	29 00	3 50	3 13	05	04	07	08	12	08
Venango,	80	58	48	63	55	9 50	12 00	100 00	150 00	33 00	2 00	3 00	....	04	04	07	13	07
Warren,	90	58	68	70	60	15 50	13 33	175 00	....	30 00	2 25	2 75	08	05	07	08	12	09
Washington,	60	70	40	....	....	10 00	12 00	100 00	....	34 00	2 38	2 50	06	04	07	08	15	11
Wayne,	....	70	45	60	55	10 00	11 00	120 00	....	32 00	[illegible]	1 00	05	04	07	07	11	09
Westmoreland,	62	75	41	59	....	13 00	14 00	93 00	150 00	30 00	3 55	4 00	06	05	06	08	14	11
Wyoming,	75	67	40	59	54	14 00	13 50	100 00	100 00	35 00	4 25	5 00	06	04	08	09	14	11
York,	69	55	33	57	57	12 00	14 50	70 00	88 00	38 00	2 50	4 50	05	05	06	07	14	11
	$0.73	$0.45	$0.37	$0.53	$0.43	$9.43	$10 47	$84 00	$77 00	$28 00	$2 76	$2 81	$0.05	$0.03	$0.06	$0.06	$0.11	$0.08

CROP REPORTS FOR 1902—Continued.

Counties.	Vegetables, Fruit, Etc.													
	Apples, per bushel.	Peaches, per basket.	Pears, per bushel.	Plums, per quart.	Cherries, per quart.	Blackberries, per quart.	Raspberries, per quart.	Potatoes, per bushel.	Butter, per lb., at store.	Butter, per lb., at market.	Milk, wholesale, per 100 lbs.	Milk, retail, per quart.	Eggs, per dozen.	Tobacco leaf, per lb.
Adams,	$0.67	$0.89	$0.75	$0.07	$0.06	$0.06	$0.08	$0.46	$0.19	$0.24	$0.82	$0.05	$0.18	$0.10
Allegheny,	88	92	1 25	10	14	11	13	65	23	[illegible]	....	06	27	....
Armstrong,	60	1 25	1 25	10	07	06	10	60	24	[illegible]	....	06	18	....
Beaver,	78	1 10	1 12	10	09	08	09	53	27	25	85	08	23	....
Bedford,	50	80	55	....	05	04	05	43	20	22	....	06	20	....
Berks,	55	82	65	05	06	08	08	45	19	25	89	05	18	09
Blair,	50	1 25	1 00	05	10	08	10	50	24	24	1 00	06	23	....
Bradford,	31	87	60	05	08	07	09	45	20	20	1 18	05	19	....
Bucks,	52	82	66	10	10	10	13	50	26	29	1 50	07	22	....
Butler,	57	1 25	1 25	10	10	07	09	50	21	20	1 50	06	21	....
Cambria,	44	1 28	1 00	10	10	08	10	50	25	25	....	06	25	....
Cameron,	75	....	1 00	....	06	09	11	57	22	24	....	06	27	10
Carbon,	40	1 00	1 00	06	07	06	08	50	21	23	1 75	07	22	....
Centre,	30	95	75	05	06	06	06	55	16	18	1 56	04	19	....
Chester,	60	83	63	06	08	09	13	45	23	27	3 50	07	25	....
Clarion,	45	1 00	1 00	....	06	06	10	60	18	22	1 00	06	20	....
Clearfield,	50	1 00	1 00	11	10	08	12	50	23	30	....	06	23	....
Clinton,	40	78	86	07	08	06	08	50	21	24	....	05	20	14
Columbia,	32	86	78	05	08	07	09	45	20	18	2 27	06	17	....
Crawford,	30	90	68	10	09	10	09	55	18	19	75	05	19	....
Cumberland,	47	75	62	08	07	05	07	50	19	24	1 13	06	17	15
Dauphin,	60	60	70	04	04	04	08	57	25	27	1 30	06	18	....
Delaware,	42	55	60	04	08	10	08	55	30	33	2 33	04	26	....
Elk,	60	....	1 00	05	08	05	10	55	25	20	1 40	05	23	....
Erie,	77	50	75	07	09	07	08	70	21	24	87	05	20	....

Fayette,	87	....	1 30	10	10	09	10	60	28	23	90	06	27	....
Forest,	60	1 33	1 10	05	11	06	10	66	20	22	2 00	05	20	....
Franklin,	70	75	80	07	07	06	09	50	20	22	1 02	05	21	....
Fulton,	50	75	80	05	06	05	05	45	17	23	....	05	17	....
Greene,	77	1 00	1 00	12	12	10	11	50	17	22	2 10	07	17	....
Huntingdon,	50	1 00	1 25	06	05	07	08	50	18	23	....	06	29	....
Indiana,	58	1 30	1 00	08	07	05	07	80	18	18	....	06	18	....
Jefferson,	50	95	1 13	08	07	07	08	55	19	21	....	06	18	....
Juniata,	45	1 00	85	05	04	03	06	50	17	24	75	05	23	....
Lackawanna,	[illegible]	75	90	05	06	09	11	65	23	24	1 20	07	23	....
Lancaster,	1 00	1 00	1 00	10	09	08	09	45	21	25	....	05	18	09
Lawrence,	70	1 50	1 60	10	10	12	11	55	19	23	1 20	06	22	....
Lebanon,	50	75	80	09	06	08	09	40	23	25	1 10	05	20	08
Lehigh,	55	95	60	10	08	08	09	45	22	21	85	05	22	....
Luzerne,	55	1 00	90	05	10	08	10	55	22	25	1 50	07	21	....
Lycoming,	45	1 00	1 00	10	07	09	10	57	19	22	1 50	06	20	....
McKean,	50	....	1 00	....	....	05	10	80	20	....	1 00	05	20	....
Mercer,	55	57	1 37	06	08	07	09	62	18	20	87	05	18	....
Mifflin,	55	92	95	07	07	07	09	57	20	21	....	05	19	....
Monroe,	50	1 05	1 33	10	08	08	09	45	24	25	1 25	05	23	....
Montgomery,	62	78	69	08	08	09	12	50	26	29	1 50	06	25	....
Montour,	50	75	92	07	07	11	11	55	20	24	2 75	06	19	....
Northampton,	40	75	73	06	07	09	10	50	23	27	1 18	06	25	....
Northumberland,	38	88	76	08	07	08	09	60	21	25	2 75	06	20	....
Perry,	45	72	53	07	08	08	08	35	18	16	2 50	05	21	....
Philadelphia,	45	1 00	1 00	05	05	06	06	50	25	25	2 28	05	25	....
Pike,	45	1 00	1 00	05	05	06	06	50	25	25	2 28	05	25	....
Potter,	45	80	1 00	06	08	05	08	45	22	24	1 35	06	24	....
Schuylkill,	45	1 15	1 00	09	08	06	10	47	25	28	1 25	06	24	....
Snyder,	37	80	75	04	04	04	07	50	15	16	2 50	05	20	....
Somerset,	40	1 00	1 00	09	08	08	10	55	21	25	1 00	05	20	....
Sullivan,	51	1 00	63	....	....	04	05	65	18	18	....	04	12	....
Susquehanna,	38	1 14	65	10	08	08	08	60	23	25	1 17	04	22	....
Tioga,	35	1 00	50	08	10	08	09	50	23	20	85	05	20	12
Union,	62	63	63	07	05	05	08	40	18	20	2 00	06	18	....
Venango,	50	1 25	1 00	06	08	07	10	55	21	24	2 50	07	18	....
Warren,	60	1 13	1 00	07	10	10	12	62	23	22	3 00	06	18	....
Washington,	1 00	....	1 50	....	....	10	11	60	21	28	1 50	07	24	....
Wayne,	73	1 25	75	....	10	07	09	50	23	21	1 00	05	21	....
Westmoreland,	1 00	....	2 00	....	10	....	13	58	26	25	....	06	23	....
Wyoming,	50	1 25	1 00	07	08	08	10	57	22	21	88	05	22	....
York,	60	1 13	70	08	09	10	10	[illegible]	20	23	70	05	20	08
Total,	$0.35	$0.75	$0.81	$0.06	$0.06	$0.07	$0.08	$0.50	$0.18	$0.22	$1 16	$0.05	$0.18	$0.10

CROP REPORTS FOR 1902 - Continued.

Counties.	Wool. Short, unwashed.	Wool. Short, washed.	Wool. Medium, unwashed.	Wool. Medium, washed.	Wool. Long, unwashed.	Wool. Long, washed.	Farm Land. Value per acre. Improved.	Farm Land. Value per acre. Average.	Farm Wages. By year, with board.	Farm Wages. Summer months only.	Farm Wages. By day, with board.	Farm Wages. By day, without board.	Farm Wages. Whole year, without board.	Farm Wages. Harvest, by day.	Farm Wages. Household help, female, with board, per week.
Adams,	$0.15	$0.19	$0.14	$0.17	$0.18	$0.22	$40 00	$37 00	$1[illegible]	$14 00	[illegible]	$1 1[illegible]	$[illegible]	$1 1[illegible]	$1 [illegible]
Allegheny,	[illegible]	27	19	24	21	23	82 00	57 00	175 00	23 00	1 [illegible]	1 [illegible]	27[illegible]	2 [illegible]	[illegible]
Armstrong,	14	18	18	24	18	24	45 00	30 00	221 00	23 00	1 [illegible]	1 40	[illegible]	1 [illegible]	[illegible]
Beaver,	17	22	19	25	17	22	33 00	25 00	[illegible]	23 00	1 [illegible]	1 40	[illegible]12 00	1 40	[illegible]
Bedford,	....	17	18	27	....	....	53 00	38 00	11[illegible]	13 00	[illegible]	1 12	....	1 [illegible]	[illegible]
Berks,	....	....	....	....	....	....	40 00	35 00	12[illegible]	13 00	75	1 [illegible]	[illegible]	1 [illegible]	1 [illegible]
Blair,	19	....	19	....	....	....	....	40 00	[illegible]	37 00	1 [illegible]	1 [illegible]	[illegible]	2 [illegible]	....
Bradford,	18	26	20	28	20	28	46 00	25 00	[illegible]	20 00	1 [illegible]	1 [illegible]	[illegible]	1 [illegible]	2 [illegible]
Bucks,	....	....	....	....	....	....	66 00	46 00	172 00	19 00	1 [illegible]	1 [illegible]	2[illegible]	1 [illegible]	[illegible]
Butler,	....	....	....	....	....	....	45 00	30 00	[illegible]	23 00	1 [illegible]	1 [illegible]	[illegible]	1 [illegible]	2 [illegible]
Cambria,	16	22	18	25	22	27	40 00	35 00	21[illegible]	21 00	1 [illegible]	1 [illegible]	[illegible]	1 [illegible]	[illegible]
Cameron,	....	....	....	....	....	....	25 00	....	....	20 00	1 2[illegible]	1 7[illegible]	....	2 [illegible]	2 [illegible]
Carbon,	....	....	....	....	....	....	40 00	30 00	[illegible]	20 00	1 [illegible]	1 [illegible]	....	1 2[illegible]	2 [illegible]
Centre,	16	16	16	21	21	24	40 00	31 00	137 [illegible]	16 00	75	1 [illegible]	2[illegible]	1 1[illegible]	1 7[illegible]
Chester,	....	....	....	....	....	....	100 00	70 00	150 [illegible]	20 00	[illegible]	1 [illegible]	2[illegible]	1 7[illegible]	2 [illegible]
Clarion,	....	....	19	28	....	....	46 00	22 00	1[illegible]	19 00	1 [illegible]	1 50	....	1 10	2 [illegible]
Clearfield,	....	....	....	....	....	....	25 00	15 00	....	25 00	1 10	1 [illegible]	....	1 [illegible]	[illegible]
Clinton,	18	....	....	....	....	....	72 00	43 00	1[illegible]	14 00	75	1 [illegible]	....	1 1[illegible]	2 [illegible]
Columbia,	14	35	18	27	20	30	50 00	30 00	1[illegible]	18 00	1 [illegible]	1 [illegible]	21[illegible]	1 [illegible]	2 [illegible]
Crawford,	18	26	19	27	18	27	35 00	25 00	1[illegible]	20 00	1 [illegible]	1 [illegible]	[illegible]	1 [illegible]	2 [illegible]
Cumberland,	....	....	....	....	....	....	81 00	51 00	14[illegible]	14 00	[illegible]	1 [illegible]	[illegible]	1 2[illegible]	1 [illegible]
Dauphin,	....	....	....	....	....	....	68 00	40 00	11[illegible]	15 00	1 [illegible]	1 25	[illegible]	1 [illegible]	2 00
Delaware,	....	....	....	....	....	....	90 00	68 00	[illegible]	28 00	1 20	1 [illegible]	[illegible]	2 [illegible]	3 00
Elk,	....	....	20	20	20	30	....	....	[illegible]	35 00	1 [illegible]	2 [illegible]	[illegible]	[illegible]	[illegible] 00
Erie,	11	18	16	20	....	....	53 00	50 00	216 00	22 00	1 [illegible]	1 [illegible]	[illegible]	1 7[illegible]	2 40

Fayette,	21	25	......	......	21	23	100 00	60 00	225 00	25 00	1 00	1 40	300 00	1 25	2 75
Forest,	18	20	19	22	17	21	30 00	10 00	180 00	35 00	1 00	1 50	250 00	1 90	2 50
Franklin,	16	21	17	21	20	23	72 00	50 00	150 00	15 00	80	1 10	......	1 37	3 00
Fulton,	14	22	18	......	......	......	50 00	35 00	130 00	13 00	60	58	225 00	1 30	1 50
Greene,	16	21	19	24	20	27	63 00	45 00	187 00	22 00	1 00	1 35	300 00	1 37	2 25
Huntingdon,	......	......	16	......	16	......	36 00	12 00	150 00	......	75	......	......	1 30	1 50
Indiana,	16	20	19	21	20	22	45 00	35 00	175 00	23 00	1 15	1 50	300 00	1 50	2 25
Jefferson,	......	......	......	......	......	......	40 00	29 00	245 00	25 00	1 13	1 60	......	1 62	3 00
Juniata,	18	28	12	20	18	28	80 00	32 00	136 00	12 00	63	85	175 00	1 00	1 30
Lackawanna,	12	24	18	26	18	26	75 00	45 00	190 00	17 00	1 00	1 30	288 00	1 50	2 25
Lancaster,	17	22	15	21	23	26	40 00	......	160 00	15 00	90	1 25	260 00	1 30	2 00
Lawrence,	16	22	18	25	18	25	50 00	40 00	230 00	23 00	1 20	1 50	325 00	1 60	3 00
Lebanon,	......	......	......	......	......	......	80 00	60 00	133 00	18 00	1 00	1 20	220 00	1 35	3 00
Lehigh,	24	26	28	29	30	33	75 00	55 00	160 00	17 00	1 00	1 35	28 000	1 25	2 50
Luzerne,	......	......	......	......	......	......	60 00	45 00	195 00	17 00	90	1 15	300 00	1 25	2 00
Lycoming,	15	30	12	25	......	......	65 00	42 00	160 00	16 00	95	1 20	165 00	1 35	2 00
McKean,	17	......	......	......	......	......	40 00	20 00	160 00	22 00	1 10	1 35	150 00	1 75	3 00
Mercer,	14	23	15	25	15	22	41 00	30 00	200 00	20 00	1 00	1 43	200 00	1 33	2 75
Mifflin,	......	......	16	......	......	......	60 00	44 00	165 00	23 00	83	1 13	250 00	1 13	1 34
Monroe,	......	......	......	......	......	......	40 00	23 00	159 00	16 00	1 00	1 20	110 00	1 00	3 00
Montgomery,	......	......	13	......	......	......	70 00	57 00	187 00	23 00	1 13	1 48	425 00	1 44	2 63
Montour,	18	19	19	20	20	22	75 00	39 00	154 00	15 00	83	2 08	258 00	1 [illegible]	2 75
Northampton,	14	16	11	16	14	16	[illegible] 00	58 00	145 00	15 00	1 09	1 44	283 00	1 [illegible]	2 17
Northumberland,	16	24	......	......	......	......	42 00	38 00	150 00	15 00	75	1 12	247 00	1 37	200
Perry,	13	18	10	......	......	......	80 00	35 00	118 00	13 00	75	1 02	108 00	1 08	1 75
Priladelphia,	17	25	......	......	......	......	63 00	40 00	120 00	18 00	84	1 05	275 00	1 38	2 25
Pike,	17	25	......	......	......	......	63 00	40 00	120 00	18 00	84	1 05	275 00	1 08	2 25
Potter,	13	21	17	......	......	......	38 00	20 00	176 00	20 00	1 00	1 50	275 00	1 50	2 50
Schuylkill,	......	......	......	......	......	......	40 00	25 00	165 00	20 00	75	1 09	319 00	1 34	2 67
Snyder,	......	......	......	28	......	......	70 00	43 00	140 00	15 00	88	1 13	228 00	1 00	2 00
Somerset,	23	25	[illegible]	22	......	......	88 00	50 00	204 00	20 00	1 43	1 [illegible]	288 00	1 50	2 33
Sullivan,	17	......	20	27	......	......	18 00	15 00	123 00	23 00	1 00	1 50	150 00	1 35	2 00
Susquehanna,	......	......	18	......	......	......	32 00	20 00	200 00	21 00	1 00	1 25	275 00	1 66	2 00
Tioga,	13	23	16	......	18	......	58 00	20 00	240 00	13 00	1 00	1 [illegible]	[illegible] 00	1 70	2 [illegible]
Union,	......	......	......	......	......	......	78 00	63 00	148 00	10 00	83	1 [illegible]	[illegible] 00	1 1[illegible]	1 63
Venango,	14	19	17	22	12 & 17	23	27 00	12 00	186 00	20 00	1 00	1 50	......	1 50	2 25
Warren,	19	......	......	......	......	......	[illegible] 00	20 00	1[illegible]4 00	21 00	1 00	1 50	260 00	1 53	2 84
Washington,	18	21	18	11	19	21	80 00	65 00	216 00	20 00	1 25	1 75	200 00	2 00	2 50
Wayne,	13	21	......	......	......	......	70 00	17 00	278 00	20 00	1 10	1 25	250 00	1 75	2 50
Westmoreland,	......	......	......	......	......	......	100 00	50 00	208 00	24 00	1 13	1 65	300 00	1 50	3 00
Wyoming,	20	24	24	20	20	21	70 00	39 00	170 00	19 00	1 00	2 00	336 00	1 67	2 41
York,	......	......	......	......	......	......	48 00	25 00	111 00	15 00	88	1 [illegible]	24 00	1 13	2 75
Total,	$0.16	$0.17	$0.17	$0.20	$0.15	$0.24	$49 00	$33 00	$173 00	$17 00	$0.86	$1 15	$196 00	$1 23	$2 05

TABLE NO. 1.

COMPOSITION OF FEEDING STUFFS.

Giving the Maximum, Minimum and Average for Each Ingredient.

From Farm Bulletin No. 22 of the Department of Agriculture, Washington, D. C.

The figures given do not represent the results of single analyses, but are the highest and lowest results which have been found in the case of each ingredient. They are given to show the limits within which each ingredient has been found to vary.

Composition of Feeding Stuffs.

	Water.	Ash.	Protein.	Fiber.	Nitrogen-free extract.	Fat.	Number of analyses.
GREEN FODDER.							
Corn fodder:*							
Flint varieties—	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	
Minimum,	51.1	0.7	0.6	2.1	4.3	0.3	....
Maximum,	90.8	1.8	4.0	11.4	36.3	1.3	....
Average,	79.8	1.1	2.0	4.3	12.1	0.7	40
Flint varieties cut after kernels had glazed—							
Minimum,	69.7	0.9	1.5	3.0	10.0	0.6	....
Maximum,	83.7	1.7	2.7	6.1	19.7	1.3	....
Average,	77.1	1.1	2.1	4.3	14.6	0.8	10
Dent varieties—							
Minimum,	59.5	0.6	0.5	2.0	3.0	0.1	....
Maximum,	93.6	2.5	3.8	11.0	27.0	1.6	....
Average,	79.0	1.2	1.7	5.6	12.0	0.5	63
Dent varieties cut after kernels had glazed—							
Minimum,	59.5	1.0	1.0	5.4	11.6	0.4	....
Maximum,	80.7	2.2	3.3	8.5	27.0	1.6	....
Average,	73.4	1.5	2.0	6.7	15.5	0.9	7
Sweet varieties							
Minimum,	69.3	0.8	0.9	1.9	3.2	0.1	....
Maximum,	92.9	2.6	2.7	8.5	19.4	1.0	....
Average,	79.1	1.3	1.9	4.4	12.8	0.5	21

*Corn fodder is the entire plant, usually a thickly planted crop. Corn stover is what is left after the ears are harvested.

Composition of Feeding Stuffs—Continued.

	Water.	Ash.	Protein.	Fiber.	Nitrogen-free extract.	Fat.	Number of analyses.
GREEN FODDER—Continued.							
All varieties—	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	
Minimum,	51.5	0.6	0.5	1.9	3.0	0.1	....
Maximum,	93.6	2.6	4.0	11.4	36.3	1.6	....
Average,	79.3	1.2	1.8	5.0	12.2	0.5	126
Leaves and husks, cut green—							
Minimum,	57.9	2.1	1.8	6.6	16.7	1.0	....
Maximum,	71.3	4.4	2.4	12.5	22.2	1.3	....
Average,	66.2	2.9	2.1	8.7	19.0	1.1	4
Stripped stalks, cut green—							
Minimum,	74.5	0.6	0.4	6.7	14.2	0.4	....
Maximum,	77.4	0.8	0.6	8.8	16.0	0.6	....
Average,	76.1	0.7	0.5	7.3	14.9	0.5	4
Rye fodder:							
Minimum,	74.4	1.3	2.3	4.7	4.9	0.2	....
Maximum,	84.3	2.4	3.0	14.9	12.4	0.7	....
Average,	76.6	1.8	2.6	11.6	6.8	0.6	7
Oat fodder:							
Minimum,	31.3	1.5	1.5	7.1	10.8	0.4	....
Maximum,	78.6	4.2	6.1	16.8	39.8	3.0	....
Average,	62.2	2.5	3.4	11.2	19.3	1.4	6
Redtop,* in bloom:							
Minimum,	51.5	1.7	2.0	8.0	11.7	0.6	....
Maximum,	76.2	2.9	4.3	15.7	21.9	1.1	....
Average,	65.3	2.3	2.8	11.0	17.7	0.9	5
Tall oat grass,† in bloom:							
Minimum,	62.3	1.6	1.7	9.2	13.0	0.6	....
Maximum,	73.5	3.0	3.3	9.7	20.7	1.5	....
Average,	69.5	2.0	2.4	9.4	15.8	0.9	3
Orchard grass, in bloom:							
Minimum,	66.9	1.6	1.9	5.8	9.9	0.7	....
Maximum,	77.3	2.9	4.1	11.1	16.6	1.3	....
Average,	73.0	2.0	2.6	8.2	13.3	0.9	4
Meadow fescue, in bloom:							
Minimum,	67.6	1.6	1.8	10.2	12.5	0.7	....
Maximum,	73.2	2.0	2.7	11.3	15.7	1.1	....
Average,	69.9	1.8	2.4	10.8	14.3	0.8	4
Italian rye grass, coming into bloom:							
Minimum,	69.6	2.1	2.6	5.5	11.5	1.1	....
Maximum,	76.6	2.8	3.8	7.5	15.4	1.6	....
Average,	73.2	2.5	3.1	6.8	13.3	1.3	24
Timothy,‡ at different stages:							
Minimum,	47.0	1.4	1.3	5.1	10.1	0.6	....
Maximum,	78.7	3.2	3.8	19.4	28.6	2.0	....
Average,	61.6	2.1	3.1	11.8	20.2	1.2	56
Kentucky blue grass, § at different stages:							
Minimum,	51.7	1.6	2.4	3.8	6.5	0.8	....
Maximum,	32.5	4.8	7.2	13.4	25.6	1.9	....
Average,	65.1	2.8	4.1	9.1	17.6	1.3	18
Hungarian grass:							
Minimum,	62.7	1.9	2.8	7.6	9.1	0.5	....
Maximum,	78.3	2.2	3.2	10.8	20.1	1.1	....
Average,	71.1	1.7	3.1	9.2	14.2	0.7	14
Red clover, at different stages:							
Minimum,	47.1	0.9	1.7	1.8	3.5	0.3	....
Maximum,	91.8	4.0	7.1	14.7	25.8	1.8	....
Average,	70.8	2.1	4.4	8.1	13.5	1.1	43
Alsike clover, ** in bloom:							
Minimum,	72.3	1.9	3.6	5.3	10.8	0.6	....
Maximum,	77.3	2.1	4.2	9.4	11.5	1.2	....
Average,	74.8	2.0	3.9	7.4	11.0	0.9	4
Crimson clover:							
Minimum,	[illegible]	1.4	2.7	[illegible]	[illegible]	[illegible]	....
Maximum,	84.6	2.0	3.5	6.3	9.7	0.8	....
Average,	80.9	1.7	3.1	5.2	8.4	0.7	3
Alfalfa, †† at different stages:							
Minimum,	49.3	1.8	3.5	2.5	10.8	0.6	....
Maximum,	82.0	5.1	7.7	14.8	11.5	1.2	....
Average,	71.8	2.7	4.8	7.4	12.3	1.0	23

*Herd's grass of Pennsylvania.
†Meadow oat grass.
‡Herd's grass of New England and New York.
§June grass.
**Swedish clover.
††Lucern.

Composition of Feeding Stuffs—Continued.

	Water.	Ash.	Protein.	Fiber.	Nitrogen-free extract.	Fat.	Number of analyses.
GREEN FODDER—Continued.							
Serradella, at different stages:	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	
Minimum,	[illegible]	1.8	2.1	2.0	3.9	0.4	....
Maximum,	[illegible]	[illegible]	3.6	7.8	17.1	1.8	....
Average,	[illegible]	3.2	2.7	5.4	8.6	0.7	9
Cowpea:							
Minimum,	72.8	1.2	1.5	1.7	1.8	1.2	....
Maximum,	[illegible]	2.7	3.5	15.3	12.9	0.6	....
Average,	[illegible]	1.7	2.4	4.8	7.1	0.4	10
Soja bean:							
Minimum,	[illegible]	1.8	2.2	4.8	[illegible]	[illegible]	....
Maximum,	[illegible]	5.1	[illegible]	9.7	[illegible]	[illegible]	....
Average,	77.1	[illegible]	4.0	6.7	[illegible]	1.0	27
Horse bean:							
Average,	84.2	1.2	2.8	4.9	6.5	0.4	2
Flat pea (Lathyrus sylvestris):							
Average,	[illegible]	[illegible]	8.7	7.9	[illegible]	1.6	2
Rape:							
Average,	84.5	2.0	2.3	2.6	8.4	0.5	2
SILAGE.							
Corn silage:							
Minimum,	62.4	[illegible]	0.7	3.0	[illegible]	0.2	....
Maximum,	87.7	[illegible]	3.6	10.5	[illegible]	[illegible]	....
Average,	79.1	1.4	1.7	6.0	11.0	0.8	99
Sorghum silage:							
Minimum,	[illegible]	[illegible]	[illegible]	[illegible]	13.8	0.1	....
Maximum,	[illegible]	1.2	[illegible]	6.8	[illegible]	0.5	....
Average,	76.1	1.1	0.8	6.4	[illegible]	0.3	6
Red clover silage:							
Minimum,	[illegible]	1.9	3.0	5.1	8.1	[illegible]	....
Maximum,	[illegible]	[illegible]	5.9	13.9	[illegible]	1.6	....
Average,	[illegible]	2.6	4.2	8.4	11.6	1.2	....
Soja bean silage:							
Average,	74.2	2.8	4.1	9.7	6.9	2.2	1
Cowpea vine silage:							
Average,	[illegible]	[illegible]	[illegible]	6.0	7.6	1.5	2
Field pea vine silage:							
Average,	[illegible]	3.5	[illegible]	13.0	[illegible]	1.6	1
Silage of mixture of cowpea vines and soja bean vines, average,	[illegible]	4.5	[illegible]	9.5	11.1	1.3	1
HAY AND DRY COARSE FODDER.							
Corn fodder,* field cured:							
Minimum,	[illegible]	1.5	[illegible]	[illegible]	[illegible]	[illegible]	
Maximum,	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.5	....
Average,	42.2	2.7	[illegible]	[illegible]	[illegible]	1.6	35
Corn leaves, field cured:							
Minimum,	14.8	4.3	[illegible]	17.4	[illegible]	0.8	....
Maximum,	[illegible]	7.4	[illegible]	[illegible]	41.4	[illegible]	
Average,	[illegible]	5.5	[illegible]	21.4	[illegible]	1.4	17
Corn husks, field cured:							
Minimum,	[illegible]	.6	1.3	[illegible]	14.3	[illegible]	....
Maximum,	[illegible]	2.3	[illegible]	[illegible]	[illegible]	1.0	....
Average,	[illegible]	1.8	[illegible]	[illegible]	[illegible]	0.7	16
Corn stalks, field cured:							
Minimum,	[illegible]	0.6	1.2	[illegible]	11.2	0.3	....
Maximum,	[illegible]	2.0	[illegible]	[illegible]	[illegible]	1.0	....
Average,	68.4	1.2	1.9	[illegible]	[illegible]	0.5	15
Corn stover,† field cured:							
Minimum,	17.4	1.7	1.9	[illegible]	[illegible]	[illegible]	....
Maximum,	57.4	[illegible]	[illegible]	[illegible]	[illegible]	2.2	....
Average,	[illegible]	3.4	[illegible]	19.7	[illegible]	1.1	[illegible]
Hay from:							
Redtop,‡ cut at different stages—							
Minimum,	6.8	3.8	[illegible]	24.0	[illegible]	1.4	....
Maximum,	[illegible]	7.0	[illegible]	[illegible]	[illegible]	3.2	....
Average,	8.9	5.2	7.9	28.6	[illegible]	1.9	9

*Entire plant.
†What is left after the ears are harvested.
‡Herd's grass of Pennsylvania.

Composition of Feeding Stuffs—Continued.

	Water.	Ash.	Protein.	Fiber.	Nitrogen-free extract.	Fat.	Number of analyses.
HAY AND DRY COARSE FODDER—Continued.							
Hay from:	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	
Redtop, cut in bloom—							
Minimum,	6.8	4.8	7.8	24.0	46.8	1.5	....
Maximum,	11.6	6.5	10.4	31.8	47.8	2.3	....
Average,	8.7	4.9	8.0	29.9	46.4	2.1	3
Orchard grass—							
Minimum,	6.5	5.0	6.6	28.9	32.9	1.7	....
Maximum,	13.6	7.9	10.4	38.3	48.6	3.3	....
Average,	9 .9	6.0	8.1	32.4	41.0	2.6	10
Timothy,* all analyses—							
Minimum,	6.1	2.5	3.8	22.3	34.3	1.0	....
Maximum,	28.9	6.3	9.8	38.5	58.5	4.0	....
Average,	13.2	4.4	5.9	29.0	45.0	2.5	68
Timothy, cut in full bloom—							
Minimum,	7.0	2.5	5.0	22.2	34.4	2.0	.
Maximum,	28.9	6.0	7.5	37.1	48.5	4.0	.
Average,	15.0	4.5	6.0	29.6	41.9	3.0	12
Timothy, cut soon after bloom—							
Minimum,	7.8	3.5	4.6	25.7	37.0	1.7	....
Maximum,	21.6	5.4	8.1	33.4	51.0	3.6	....
Average,	14.2	4.4	5.7	28.1	44.6	3.0	11
Timothy, cut when nearly ripe—							
Minimum,	7.0	2.7	4.3	24.8	38.0	1.0	....
Maximum,	22.7	5.1	6.0	38.5	49.1	2.8	....
Average,	14.1	3.9	5.0	31.1	43.7	2.2	12
Timothy, cut when ripe—							
Minimum,	14.3	4.5	5.3	17.7	31.8	2.0	....
Maximum,	32.8	7.8	12.9	26.8	51.1	4.2	....
Average,	21.2	6.3	7.8	23.0	37.8	3.9	10
Cut, when seed was in milk—							
Minimum,	22.5	5.6	6.0	23.9	33.2	3.4	....
Maximum,	26.5	7.6	6.6	24.9	35.4	4.1	....
Average,	24.4	7.0	6.2	24.5	24.2	3.6	4
Cut, when seed was ripe—							
Minimum,	23.7	5.1	5.3	20.4	33.6	2.8	....
Maximum,	32.8	7.8	6.0	25.7	33.7	3.2	....
Average,	27.8	6.4	5.8	23.8	33.2	3.0	6
Hungarian grass—							
Minimum,	4.9	5.0	4.7	23.6	44.4	1.5	....
Maximum,	9.5	7.5	13.3	36.3	53.0	3.5	....
Average,	7.7	6.0	7.5	27.7	49.0	2.1	18
Meadow fescue—							
Minimum,	7.4	5.5	4.5	20.8	28.5	1.6	....
Maximum,	32.5	7.8	11.8	31.9	45.5	3.5	....
Average,	20.0	6.8	7.0	25.9	38.4	2.7	9
Italian rye grass—							
Minimum,	7.4	6.1	5.7	28.4	39.6	1.3	....
Maximum,	9.3	7.9	8.8	33.9	48.9	1.9	....
Average,	8.5	6.9	7.5	30.5	45.0	1.7	4
Mixed grasses—							
Minimum,	6.5	2.1	4.8	21.0	33.4	1.3	....
Maximum,	33.4	6.9	12.1	38.4	50.8	4.9	....
Average,	15.3	5.5	7.4	27.2	41.1	2.5	126
Rowen, (mixed)†—							
Minimum,	8.2	5.1	9.6	20.1	33.6	2.2	....
Maximum,	24.4	7.2	14.8	20.0	44.3	4.5	....
Average,	16.6	6.8	11.6	22.5	39.4	3.1	23
Mixed grasses and clovers—							
Minimum,	8.2	3.9	5.5	19.7	31.8	1.5	....
Maximum,	25.9	9.6	14.4	25.1	48.9	3.1	....
Average,	19.9	5.5	10.1	27.6	41.3	2.6	17
Swamp hay—							
Minimum,	7.8	3.3	5.0	19.4	39.9	0.8	....
Maximum,	17.9	12.1	8.8	31.6	51.7	3.6	....
Average,	11.6	6.7	7.2	26.6	45.9	2.0	8
Salt marsh—							
Minimum,	7.8	5.4	4.0	25.1	34.1	1.6	....
Maximum,	18.6	11.8	7.8	33.8	54.3	3.1	....
Average,	10.4	7.7	5.5	30.0	44.1	2.4	14

*Herd's grass of New England and New York.
†Second cut.

Composition of Feeding Stuffs—Continued.

	Water.	Ash.	Protein.	Fiber.	Nitrogen-free extract.	Fat.	Number of analyses.
HAY AND DRY COARSE FODDER—Continued.							
Hay from:	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	
Red clover—							
Minimum,	6.0	3.9	10.0	15.6	27.3	1.5	....
Maximum,	31.3	8.3	20.2	35.7	52.2	5.9	....
Average,	15.3	6.2	12.3	24.8	38.1	3.3	38
Red clover in bloom—							
Minimum,	6.6	5.6	10.8	17.9	27.3	2.5	....
Maximum,	31.3	8.3	15.4	28.1	41.3	5.9	....
Average,	20.8	6.6	12.4	21.9	33.8	4.5	6
Alsike clover—							
Minimum,	5.3	6.1	9.2	19.7	35.6	1.6	....
Maximum,	13.9	12.3	16.1	29.5	45.9	4.2	....
Average,	9.7	8.3	12.8	25.6	40.7	2.9	9
White clover—							
Minimum,	6.1	4.5	13.9	20.3	33.4	1.7	....
Maximum,	13.5	13.8	20.0	30.3	47.3	5.8	....
Average,	9.7	8.3	15.7	24.1	39.3	2.9	7
Crimson clover—							
Minimum,	5.9	7.4	13.6	20.1	29.3	1.5	....
Maximum,	13.4	13.0	16.1	34.9	42.6	4.8	....
Average,	9.6	8.6	15.2	27.2	36.6	2.8	7
Japan clover—							
Average,	11.0	8.5	13.8	24.0	39.0	3.7	2
Vetch—							
Minimum,	8.3	7.1	13.1	19.7	26.5	1.6	....
Maximum,	15.8	11.6	23.1	28.1	40.2	3.0	....
Average,	11.3	7.9	17.0	25.4	36.1	2.3	5
Serradella—							
Minimum,	7.2	5.4	13.9	19.4	40.5	2.2	....
Maximum,	11.7	10.3	16.6	22.9	46.6	2.9	....
Average,	9.2	7.2	15.2	21.6	44.2	2.6	2
Alfalfa*—							
Minimum,	4.6	3.1	10.2	14.0	35.1	1.1	....
Maximum,	16.0	10.4	23.3	33.0	53.6	3.8	....
Average,	8.4	7.4	14.3	25.0	42.7	2.2	21
Cowpea—							
Minimum,	7.6	3.2	13.6	16.4	39.4	1.1	....
Maximum,	14.0	10.2	20.3	25.0	49.5	3.7	....
Average,	10.7	7.5	16.6	20.1	42.2	2.2	8
Soja bean—							
Minimum,	6.1	4.8	14.0	17.3	31.8	2.4	....
Maximum,	20.1	8.9	18.1	32.3	41.0	7.5	....
Average,	11.3	7.2	15.4	22.3	38.6	5.2	6
Flat pea (Lathyrus sylvestris)—							
Minimum,	6.2	6.5	17.6	18.5	27.7	1.6	....
Maximum,	10.0	8.6	27.9	32.7	31.0	4.6	....
Average,	8.4	7.9	22.9	26.2	31.4	3.2	5
Peanut vines (without nuts)—							
Minimum,	6.3	7.3	9.1	18.2	23.1	1.7	....
Maximum,	.7.8	15.7	11.7	33.3	50.4	5.8	....
Average,	7.6	10.8	10.7	23.6	42.7	4.6	6
Soja bean straw:							
Minimum,	5.7	3.9	4.0	34.0	35.3	0.8	....
Maximum,	14.0	4.9	4.9	49.6	43.3	3.2	....
Average,	10.1	5.8	4.6	40.4	37.4	1.7	4
Horse bean straw:							
Average,	9.2	8.7	8.8	37.6	34.3	1.4	1
Wheat straw:							
Minimum,	6.5	3.0	2.9	34.3	31.0	0.8	....
Maximum,	17.9	7.0	5.0	42.7	50.6	1.8	....
Average,	9.6	4.2	3.4	38.1	43.4	1.3	7
Rye straw:							
Minimum,	6.3	2.8	2.2	32.7	41.0	1.0	....
Maximum,	9.7	3.4	3.6	43.3	52.9	1.6	....
Average,	7.1	3.2	3.0	38.9	46.6	1.2	7
Oat straw:							
Minimum,	6.5	3.7	2.7	31.8	33.5	1.7	....
Maximum,	11.4	6.7	6.9	45.1	46.6	3.2	....
Average,	9.2	5.1	4.0	37.0	42.4	2.3	12

*Lucern.

Composition of Feeding Stuffs—Continued.

	Water.	Ash.	Protein.	Fiber.	Nitrogen-free extract.	Fat.	Number of analyses.
HAY AND DRY COARSE FODDER—Continued.							
Hay from:	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	
Buckwheat straw:							
Minimum,	9.0	4.9	3.3	37.2	32.1	0.7	....
Maximum,	10.4	6.5	7.8	46.8	38.9	1.7	....
Average,	9.9	5.5	5.2	43.0	35.1	1.3	3
ROOTS AND TUBERS.							
Potatoes:							
Minimum,	75.4	0.8	1.1	0.3	14.1	....	....
Maximum,	82.2	1.2	3.0	0.9	20.4	0.1	....
Average,	78.9	1.0	2.1	0.6	17.3	0.1	12
Sweet potatoes:							
Minimum,	66.0	0.7	0.5	0.6	18.0	0.3	....
Maximum,	74.4	1.3	3.6	2.5	29.7	0.6	....
Average,	71.1	1.0	1.5	1.3	24.7	0.4	6
Red beets:							
Minimum,	85.8	0.7	1.1	0.6	3.3	0.1	....
Maximum,	92.2	1.6	1.8	1.7	11.3	0.3	....
Average,	88.5	1.0	1.5	0.9	8.0	0.1	9
Sugar beets:							
Minimum,	85.0	0.4	1.1	0.6	5.7	0.1	....
Maximum,	90.8	1.2	3.2	1.3	13.6	0.2	....
Average,	86.5	0.9	1.8	0.9	9.8	0.1	19
Mangel-wurzels:							
Minimum,	86.9	0.8	1.0	0.6	2.4	0.1	....
Maximum,	94.4	1.4	1.9	1.3	8.7	0.5	....
Average,	90.9	1.1	1.4	0.9	5.5	0.2	9
Turnips:							
Minimum,	87.2	0.7	0.8	0.8	4.2	0.1	....
Maximum,	92.4	1.0	1.4	1.4	8.8	0.2	....
Average,	90.5	0.8	1.1	1.2	6.2	0.2	3
Rutabagas:							
Minimum,	87.1	1.0	1.0	1.1	5.1	0.1	....
Maximum,	91.8	1.4	1.3	1.4	9.1	0.3	....
Average,	88.6	1.2	1.2	1.3	7.5	0.2	4
Carrots:							
Minimum,	86.5	1.6	0.8	0.9	5.1	0.2	....
Maximum,	91.1	1.3	2.0	2.3	10.4	0.7	....
Average,	88.6	1.0	1.1	1.3	7.6	0.4	8
Artichokes:							
Average,	79.5	1.0	2.6	0.8	15.9	0.2	2
GRAINS AND OTHER SEEDS.							
Corn kernels:							
Dent, all analyses—							
Minimum,	6.2	1.0	7.5	0.9	65.9	3.1	....
Maximum,	19.4	2.6	11.8	4.8	75.7	7.5	....
Average,	10.6	1.5	10.3	2.2	70.4	5.0	86
Flint, all analyses—							
Minimum,	4.5	1.0	7.0	0.7	65.0	3.4	....
Maximum,	19.6	1.9	13.7	2.9	76.7	7.1	....
Average,	11.3	1.4	10.5	1.7	70.1	5.0	68
Sweet, all analyses—							
Minimum,	6.0	1.4	9.5	1.5	61.8	3.8	....
Maximum,	10.9	2.4	15.3	5.2	72.4	9.3	....
Average,	8.8	1.9	11.6	2.8	66.8	8.1	26
Pop varieties—							
Minimum,	8.6	1.2	9.7	1.2	68.4	4.2	....
Maximum,	11.8	1.7	13.1	2.3	71.1	6.6	....
Average,	10.7	1.5	11.2	1.8	69.6	5.2	4
Soft varieties—							
Minimum,	6.1	1.4	8.8	1.3	66.0	5.0	....
Maximum,	14.1	1.9	14.6	3.3	75.5	5.7	....
Average,	9.3	1.6	11.4	2.0	70.2	5.5	5
All varieties and analyses—							
Minimum,	4.5	1.0	7.0	0.7	61.8	3.1	....
Maximum,	20.7	2.6	15.3	5.2	76.7	9.3	....
Average,	10.9	1.5	10.5	2.1	69.6	5.4	208
Sorghum seed:							
Minimum,	9.3	1.4	7.7	1.5	59.0	2.1	....
Maximum,	16.8	4.3	11.3	8.7	73.6	4.6	....
Average,	12.8	2.1	9.1	2.6	69.8	3.6	10

Composition of Feeding Stuffs—Continued.

	Water.	Ash.	Protein.	Fiber.	Nitrogen-free extract.	Fat.	Number of analyses.
GRAINS AND OTHER SEED—Continued.							
Barley:	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	
Minimum,	7.2	1.8	8.6	1.3	66.7	1.5	....
Maximum,	12.6	3.2	15.7	4.2	73.9	3.2	....
Average,	10.9	2.4	12.4	2.7	69.8	1.8	10
Oats:							
Minimum,	8.9	2.0	8.0	1.5	53.5	3.4	....
Maximum,	13.5	4.0	14.4	12.9	66.9	5.8	....
Average,	11.0	3.0	11.8	9.5	59.7	5.0	30
Rye:							
Minimum,	8.7	1.8	9.5	1.4	71.2	1.4	....
Maximum,	13.2	1.9	12.1	2.1	73.9	2.1	....
Average,	11.6	1.9	10.6	1.7	72.5	1.7	6
Wheat, spring varieties:							
Minimum,	8.1	1.5	8.4	1.3	66.1	1.8	....
Maximum,	13.4	2.6	15.4	2.3	74.9	2.6	....
Average,	10.4	1.9	12.5	1.8	71.2	2.2	18
Wheat, winter varieties, all analyses:							
Minimum,	7.1	0.8	8.1	0.4	66.7	1.3	....
Maximum,	14.0	3.6	16.6	2.9	77.7	3.9	....
Average,	10.5	1.8	11.8	1.8	72.0	2.1	262
Wheat, all varieties:							
Minimum,	7.1	0.8	8.1	0.4	64.8	1.3	....
Maximum,	14.0	3.6	17.2	3.1	77.7	1.3	....
Average,	10.5	1.8	11.9	1.8	71.9	2.1	310
Rice:							
Minimum,	11.4	0.3	5.9	0.1	77.5	0.3	....
Maximum,	14.0	0.5	8.6	0.4	80.6	0.6	....
Average,	12.4	0.4	7.4	0.2	79.2	0.4	10
Buckwheat:							
Minimum,	10.9	1.6	8.6	7.8	62.6	2.2	....
Maximum,	14.8	2.3	11.0	9.4	65.4	2.4	....
Average,	12.6	2.3	10.0	8.7	64.5	2.2	8
Sunflower seed (whole):							
Minimum,	8.5	2.1	15.8	29.5	22.0	20.9	....
Maximum,	8.8	3.2	16.7	30.3	27.7	21.5	....
Average,	8.6	2.6	16.3	29.9	21.4	21.2	2
Cotton seed, whole (with hulls):							
Minimum,	7.0	2.9	14.5	20.3	17.3	18.9	....
Maximum,	17.5	4.5	21.7	28.7	29.1	21.6	....
Average,	10.3	3.5	18.4	23.2	24.7	19.9	5
Cotton seed kernels (without hulls):							
Minimum,	6.0	4.0	29.3	3.1	15.8	36.5	....
Maximum,	6.3	5.4	33.1	4.4	19.5	36.6	....
Average,	6.2	4.7	31.2	3.7	17.6	36.6	2
Cotton seed, whole (roasted):							
Minimum,	2.9	2.3	16.1	16.8	21.1	22.5	....
Maximum,	9.3	8.7	17.6	24.0	25.8	32.7	....
Average,	6.1	5.5	16.8	20.4	23.5	27.7	2
Peanut kernels (without hulls):							
Minimum,	4.9	1.9	23.2	2.0	12.7	35.0	....
Maximum,	13.2	3.8	31.4	18.4	19.1	47.4	....
Average,	7.5	2.4	27.9	7.0	15.6	39.6	7
Horse bean,	11.3	3.8	26.6	7.2	50.1	1.0	1
Soja bean:							
Minimum,	5.9	3.1	26.3	3.4	26.2	12.3	....
Maximum,	19.3	5.4	40.2	6.1	32.8	19.0	....
Average,	10.8	4.7	34.0	4.8	28.8	16.9	8
Cowpea:							
Minimum,	10.0	2.9	19.3	2.5	50.5	1.3	....
Maximum,	20.9	3.4	23.4	5.0	62.0	1.6	....
Average,	14.8	3.2	20.8	4.1	55.7	1.4	5
MILL PRODUCTS.							
Corn meal:							
Minimum,	8.0	0.9	7.1	0.5	60.4	2.0	....
Maximum,	27.4	4.1	13.9	3.1	74.0	5.1	....
Average,	15.0	1.4	9.2	1.9	68.7	3.8	77
Corn and cob meal:							
Minimum,	9.5	1.2	5.8	4.7	56.8	2.5	....
Maximum,	26.3	1.9	12.2	9.4	60.7	4.7	....
Average,	15.1	1.5	8.5	6.6	64.8	3.5	7

Composition of Feeding Stuffs—Continued.

	Water.	Ash.	Protein.	Fiber.	Nitrogen-free extract.	Fat.	Number of analyses.
MILL PRODUCTS—Continued.							
Oat meal:	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	
Minimum,	6.2	1.8	12.9	0.6	66.6	6.1	....
Maximum,	8.8	2.2	16.3	1.2	69.0	8.8	....
Average,	7.9	8.0	14.7	0.9	67.4	7.1	6
Barley meal:							
Minimum,	9.9	1.6	9.8	5.9	63.5	1.5	....
Maximum,	13.6	3.8	12.7	7.0	68.0	3.2	....
Average,	11.9	2.6	10.5	6.5	66.3	2.2	3
Rye flour:							
Minimum,	12.4	0.6	0.4	6.0	77.6	0.8	....
Maximum,	13.6	0.8	6.9	0.5	79.1	0.9	....
Average,	13.1	0.7	6.7	0.4	78.3	0.8	4
Wheat flour, all analyses:							
Minimum,	8.2	0.3	8.6	0.1	71.5	0.6	....
Maximum,	13.6	0.7	13.6	1.0	78.5	1 .8	....
Average,	12.4	0.5	10.8	0.2	75.0	1.1	20
Buckwheat flour:							
Minimum,	12.8	0.7	4.2	0.2	71.1	0.7	....
Maximum,	17.6	1.3	8.1	0.5	79.4	1.8	....
Average,	14.6	1.0	6.9	0.3	75.8	1.4	4
Ground linseed:							
Minimum,	7.9	3.4	20.3	5.0	25.5	30.3	....
Maximum,	8.3	6.1	23.0	6.9	30.2	30.5	....
Average,	8.1	4.7	21.6	7.3	27.9	30.4	2
Pea meal:							
Minimum,	8.9	2.6	19.1	17.1	5 0.2	0.9	....
Maximum,	12.1	2.7	21.4	17.7	52.0	1.5	....
Average,	10.5	2.6	20.2	14.4	15.1	1.2	2
Soja bean meal,	10.8	45.5	36.7	4.5	27.3	16.2	1
Ground corn and oats, equal parts:							
Minimum,	10.7	1.9	8.4	....	*70.4	4.0	....
Maximum,	[illegible]	2.7	[illegible]	....	*73.4	5.0	....
Average,	11.9	2.2	9.6	....	*72.0	4.4	6
WASTE PRODUCTS.							
Corn-cob:							
Minimum,	7.2	0.7	1.2	18.2	43.8	0.1	....
Maximum,	24.8	2.7	3.7	38.3	66.7	0.9	....
Average,	10.7	1.4	2.4	30.1	54.9	0.5	18
Hominy chops:							
Minimum,	8.1	1.9	7.9	2.5	61.0	4.5	....
Maximum,	13.5	3.1	11.2	6.7	71.1	11.2	....
Average,	11.1	2.5	9.8	3.8	64.5	8.3	12
Corn-germ:							
Minimum,	[illegible]	[illegible]	[illegible]	1.9	61.9	5.2	....
Maximum,	13.0	7.4	9.9	5.8	67.4	11.2	....
Average,	10.7	4.0	9.8	4.1	64.0	7.4	3
Corn-germ meal:							
Minimum,	6.5	0.8	10.0	7.8	57.4	4.3	....
Maximum,	9.9	2.6	14.0	13.0	67.0	11.2	....
Average,	8.1	1.3	11.1	9.9	62.5	7.1	6
Gluten meal:							
Minimum,	6.2	0.5	21.3	0.3	34.0	3.4	....
Maximum,	12.3	2.0	39.2	7.8	58.5	20.0	....
Average,	8.8	0.8	29.7	2.2	49.8	8.7	54
Recent analyses—							
Minimum,	6.2	0.5	21.4	0.6	34.0	6.6	....
Maximum,	11.1	2.0	39.3	7.8	58.4	20.0	....
Average,	8.2	0.9	29.3	3.3	46.5	11.8	20
Chicago†—							
Average,	10.1	1.1	30.1	1.6	48.7	8.4	6
Buffalo†—							
Average,	8.2	0.8	23.3	6.1	50.4	11.2	1
Cream gluten:							
Minimum,	7.7	0.6	34.1	1.2	35.0	13.6	....
Maximum,	9.0	0.8	38.2	1.3	41.1	15.8	....
Average,	8.1	0.7	36.1	1.3	39.0	14.8	....

*Including fiber.
†Included in above average.

Composition of Feeding Stuffs—Continued.

	Water.	Ash.	Protein.	Fiber.	Nitrogen-free extract.	Fat.	Number of analyses.
WASTE PRODUCTS—Continued.							
Gluten feed:	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	
Minimum,	6.3	0.7	19.5	1.5	44.5	7.0	....
Maximum,	9.0	1.8	28.3	8.2	58.0	12.6	....
Average,	7.8	1.1	24.0	5.3	41.2	10.6	11
Buffalo†—							
Average,	7.7	1.1	25.0	5.3	49.3	11.6	5
Pope's,	14.0	0.6	33.3	1.6	36.5	14.1	1
Peoria,†	7.5	0.8	19.8	8.2	51.1	12.6	1
Chicago maize feed:							
Minimum,	8.6	0.7	19.3	6.8	49.2	5.6	....
Maximum,	9.7	1.1	26.9	8.7	56.1	7.9	....
Average,	9.1	0.9	22.8	7.6	52.7	6.9	3
Glucose feed and glucose refuse:							
Average,	6.5	1.1	20.7	4.5	56.8	10.4	2
Dried starch feed and sugar feed:							
Minimum,	9.2	0.6	17.1	3.1	49.2	7.3	....
Maximum,	11.7	1.2	22.1	5.6	59.6	11.1	....
Average,	10.9	0.9	19.7	4.7	54.8	9.0	4
Starch feed, wet:							
Minimum,	62.3	0.1	3.6	1.6	18.7	1.3	....
Maximum,	72.2	0.6	9.6	4.4	28.9	4.4	....
Average,	65.4	0.3	6.1	3.1	22.0	3.1	12
Oat feed:							
Minimum,	6.4	3.2	12.6	3.7	56.2	6.1	....
Maximum,	9.2	4.2	20.0	12.5	63.7	7.8	....
Average,	7.7	3.7	16.0	6.1	59.4	7.1	4
Barley screenings:							
Minimum,	12.0	3.5	12.1	7.0	61.6	2.6	....
Maximum,	12.4	3.6	12.5	7.6	62.0	2.9	....
Average,	12.2	3.6	12.3	7.3	61.8	2.8	2
Malt sprouts:							
Minimum,	7.3	3.8	21.0	9.3	45.5	1.0	....
Maximum,	12.0	6.7	25.9	12.0	50.3	3.0	....
Average,	10.2	5.7	23.2	10.7	48.5	1.7	4
Brewers' grains, wet:							
Minimum,	68.6	0.3	4.3	3.1	9.6	0.8	....
Maximum,	79.4	1.5	6.9	5.6	15.9	2.8	....
Average,	75.7	1.0	5.4	3.8	12.5	1.6	15
Brewers' grains, dried:							
Minimum,	6.2	3.3	19.3	10.2	46.1	4.2	....
Maximum,	11.9	3.8	20.3	11.6	56.8	6.5	....
Average,	8.2	3.6	19.9	11.0	51.7	5.6	3
Grano gluten,	5.8	2.8	31.1	12.0	33.4	14.9	1
Rye bran:							
Minimum,	8.2	2.9	11.5	2.5	59.8	1.7	....
Maximum,	13.7	4.5	16.8	4.1	67.6	4.9	....
Average,	11.6	3.6	14.7	3.5	63.8	2.8	7
Wheat bran from spring wheat:							
Minimum,	7.4	4.0	14.3	5.4	51.7	3.6	....
Maximum,	13.0	6.0	18.1	10.1	58.1	5.0	....
Average,	11.5	5.4	16.1	8.0	54.5	4.5	10
Wheat bran from winter wheat:							
Minimum,	10.6	5.0	13.9	7.2	50.5	3.5	....
Maximum,	13.6	6.4	17.8	8.9	56.2	4.5	....
Average,	12.3	5.9	16.0	8.1	53.7	4.0	7
Wheat bran, all analyses:							
Minimum,	7.4	2.5	12.1	2.4	45.5	1.5	....
Maximum,	15.8	7.8	18.9	15.5	63.2	7.0	....
Average,	11.9	5.8	15.4	9.0	53.9	4.0	88
Wheat middlings:							
Minimum,	9.2	1.4	10.1	1.3	53.0	2.1	....
Maximum,	16.0	6.3	20.0	12.7	70.9	5.9	....
Average,	12.1	3.3	15.6	4.6	60.4	4.0	32
Wheat shorts:							
Minimum,	4.1	2.0	11.1	6.0	50.0	2.5	....
Maximum,	15.5	6.2	19.4	10.5	67.0	6.1	....
Average,	11.8	4.6	14.9	7.4	56.8	4.5	12
Wheat screenings:							
Minimum,	7.8	1.9	8.3	1.7	61.0	2.7	....
Maximum,	13.6	3.8	16.9	7.5	70.4	3.3	....
Average,	11.6	2.9	12.5	4.9	65.1	3.0	10

†Included in above average.

Composition of Feeding Stuffs—Continued.

	Water.	Ash.	Protein.	Fiber.	Nitrogen-free extract.	Fat.	Number of analyses.
WASTE PRODUCTS—Continued.							
	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	
Rice bran:							
Minimum,	8.8	8.4	10.9	2.0	41.9	5.2	....
Maximum,	10.7	12.4	13.6	17.8	62.3	10.9	....
Average,	9.7	10.0	12.1	9.5	49.9	8.8	5
Rice hulls:							
Minimum,	7.7	10.5	2.9	30.3	36.0	0.6	....
Maximum,	8.5	15.1	4.7	38.6	41.6	0.9	....
Average,	8.2	13.2	3.6	35.7	38.6	0.7	3
Rice polish:							
Minimum,	9.0	2.8	10.9	2.4	45.5	6.5	....
Maximum,	11.2	11.3	12.9	14.5	63.3	8.0	....
Average,	10.0	6.7	11.7	6.3	58.0	7.3	4
Buckwheat middlings:							
Minimum,	9.5	4.4	25.1	2.4	36.3	5.7	....
Maximum,	16.3	5.5	31.3	5.7	52.7	8.1	....
Average,	13.2	4.8	28.9	4.1	41.9	7.1	....
Cotton seed meal:							
Minimum,	5.8	5.7	23.3	1.3	15.7	8.8	....
Maximum,	18.5	8.8	50.8	10.1	38.7	18.0	....
Average,	8.2	7.2	42.3	5.6	23.6	13.1	35
Cotton seed hulls:							
Minimum,	9.2	1.8	2.2	37.9	12.4	0.6	....
Maximum,	16.7	4.4	5.4	67.0	41.8	5.4	....
Average,	11.1	2.8	4.2	46.3	33.4	2.2	20
Linseed meal, old process:							
Minimum,	5.6	4.6	27.7	4.7	28.4	5.2	....
Maximum,	12.4	8.2	38.2	12.9	41.9	11.6	....
Average,	9.2	5.7	32.9	8.9	35.4	7.9	21
Linseed meal, new process:							
Minimum,	6.0	5.0	27.1	7.6	35.2	1.3	....
Maximum,	13.4	6.9	38.4	4.0	48.0	4.4	....
Average,	10.1	5.8	38.2	9.5	38.4	3.0	14
Peanut meal:*							
Minimum,	6.6	3.7	37.5	2.5	28.5	5.8	....
Maximum,	15.4	5.5	52.4	7.4	30.3	17.5	....
Average,	10.7	4.9	47.6	5.1	23.7	8.0	2,430
Peanut hulls:							
Minimum,	7.8	1.9	4.6	56.5	9.7	0.9	....
Maximum,	10.8	4.6	8.6	72.3	18.9	2.0	....
Average,	9.0	3.4	6.6	64.3	15.1	1.6	5
MILK AND ITS BY-PRODUCTS.							
Whole milk:							
Minimum,	80.3	0.4	2.1	....	2.1	1.7	....
Maximum,	90.7	1.2	6.4	....	6.1	6.5	....
Average,	87.2	0.7	3.6	....	4.9	3.7	798
Skim milk, cream raised by setting:							
Minimum,	88.3	0.5	2.6	....	3.8	0.2	....
Maximum,	92.6	1.0	3.9	....	5.5	2.5	....
Average,	90.4	0.7	3.3	....	4.7	0.9	96
Skim milk, cream raised by separator:							
Minimum,	89.8	....	....	....	....	....	....
Maximum,	91.2	....	....	....	....	....	....
Average,	90.6	0.7	3.1	....	5.3	0.3	7
Buttermilk:							
Minimum,	82.2	0.4	1.7	....	2.5	....	....
Maximum,	93.3	0.9	6.2	....	5.6	5.4	....
Average,	90.1	0.7	4.0	....	4.0	1.1	85
Whey:							
Minimum,	93.2	0.3	0.3	....	4.4	0.0	....
Maximum,	94.6	0.6	1.2	....	5.8	0.2	....
Average,	93.8	0.4	0.6	....	5.1	0.1	46

*Mostly European analyses.

TABLE NO. II.

POUNDS OF TOTAL DRY MATTER, TOTAL ORGANIC MATTER AND DIGESTIBLE INGREDIENTS (PROTEIN AND CARBOHYDRATES [INCLUDING ETHER EXTRACT MULTIPLIED BY 2.25]) IN VARYING WEIGHTS OF FODDERS AND FEEDS, BEING ESSENTIALLY A CONVENIENCE TABLE.

Pounds of Fodder.	Total dry matter.	Organic matter.	Protein.	Carbohydrates, etc.	Total dry matter.	Organic matter.	Protein.	Carbohydrates, etc.	Total dry matter.	Organic matter.	Protein.	Carbohydrates, etc.
Grasses.	Pasture grass, 1:4.8.				Timothy grass, 1:14.3.				Red top grass, 1:14.6.			
2½,	0.5	0.5	0.06	0.3	1.0	0.9	0.04	0.5	0.9	0.8	0.03	0.5
5,	1.0	0.9	0.12	0.6	1.9	1.8	0.08	1.1	1.7	1.6	0.07	1.0
10,	2.0	1.8	0.23	1.1	3.8	3.6	0.15	2.1	3.5	3.2	0.13	1.9
15,	3.0	2.7	0.35	1.7	5.8	5.4	0.23	3.2	5.2	4.9	0.20	2.9
20,	4.0	3.6	0.46	2.2	7.7	7.3	0.30	4.3	6.9	6.5	0.26	3.8
25,	5.0	4.5	0.58	2.8	9.6	9.1	0.38	5.4	8.7	8.1	0.33	4.8
30,	6.0	5.4	0.69	3.3	11.5	10.9	0.45	6.4	10.4	9.7	0.39	5.7
35,	7.0	6.3	0.81	3.9	13.4	12.7	0.53	7.5	12.1	11.3	0.46	6.7
40,	8.0	7.2	0.92	4.4	15.4	14.5	0.60	8.6	13.9	13.0	0.52	7.6
Grasses.	Kentucky blue grass, 1:9.2.				Green rowen, 1:5.1.				Green fodder corn, 1:11.7.			
2½,	0.9	0.8	0.05	0.5	0.7	0.7	0.08	0.4	0.5	0.5	0.03	0.3
5,	1.8	1.6	0.10	0.9	1.5	1.4	0.16	0.8	1.0	1.0	0.06	0.6
10,	3.5	3.2	0.20	1.8	3.0	2.8	0.32	1.6	2.1	2.0	0.11	1.3
15,	5.2	4.8	0.30	2.7	4.5	4.1	0.48	2.5	3.1	2.9	0.17	1.9
20,	7.0	6.4	0.40	3.7	6.0	5.5	0.64	3.3	4.1	3.9	0.22	2.6
25,	8.7	8.0	0.50	4.7	7.5	6.9	0.80	4.1	5.2	4.9	0.28	3.2
30,	10.5	9.6	0.60	5.5	9.0	8.3	0.96	4.9	6.2	5.9	0.33	3.9
35,	12.2	11.2	0.70	6.4	10.5	9.6	1.12	5.7	7.2	6.8	0.39	4.5
40,	14.0	12.8	0.80	7.3	12.0	11.0	1.28	6.6	8.3	7.8	0.44	5.2
Green fodders.	Sweet corn fodder, 1:11.3.				Green barley fodder, 1:5.7.				Green oat fodder, 1:8.7.			
2½,	0.5	0.5	0.03	0.3	0.6	0.6	0.06	0.3	0.9	0.9	0.06	0.5
5,	1.0	1.0	0.06	0.7	1.2	1.1	0.12	0.7	1.9	1.8	0.12	1.0
10,	2.1	2.0	0.12	1.4	2.5	2.3	0.24	1.4	3.8	3.5	0.24	2.1
15,	3.1	2.9	0.18	2.1	3.7	3.4	0.36	2.1	5.7	5.3	0.36	3.1
20,	4.2	3.9	0.24	2.7	5.0	4.6	0.48	2.7	7.6	7.1	0.48	4.2
25,	5.2	4.9	0.30	3.4	6.2	5.7	0.60	3.4	9.5	8.9	0.60	5.2
30,	6.3	5.9	0.36	4.1	7.4	6.8	0.72	4.1	11.3	10.6	0.72	6.2
35,	7.3	6.8	0.42	4.8	8.7	8.0	0.84	4.8	13.2	12.3	0.84	7.3
40,	8.4	7.8	0.48	5.4	9.9	9.1	0.96	5.4	15.1	14.1	0.96	8.3

TABLE II.—POUNDS OF TOTAL DRY MATTER, TOTAL ORGANIC MATTER AND DIGESTIBLE INGREDIENTS—Continued.

Pounds of Fodder.	Total dry matter.	Organic matter.	Protein.	Carbohydrates, etc.	Total dry matter.	Organic matter.	Protein.	Carbohydrates, etc.	Total dry matter.	Organic matter.	Protein.	Carbohydrates, etc.
Green fodders.	Green rye fodder, 1:7.2.				Green Hungarian, 1:8.7.				Oats and peas, 1:4.2.			
2½,	0.6	0.5	0.07	0.4	0.7	0.7	0.07	0.4	0.5	0.5	0.07	0.3
5,	1.2	1.1	0.11	0.7	1.4	1.4	0.10	0.8	1.1	1.0	0.14	0.5
10,	2.3	2.2	0.21	1.5	2.9	2.7	0.20	1.7	2.1	2.0	0.27	1.1
15,	[illegible]	3.2	0.32	2.3	4.3	[illegible]	[illegible]	2.6	3.2	[illegible]	0.41	1.7
20,	4.7	4.3	0.42	3.0	5.8	5.4	[illegible]	3.7	4.3	3.9	0.54	2.3
25,	5.9	5.4	0.53	3.8	7.2	6.8	0.76	4.3	5.3	4.8	0.68	2.9
30,	7.0	6.5	0.63	4.5	8.7	8.2	0.60	5.2	6.4	5.9	0.81	3.4
35,	8.2	7.6	0.74	5.3	10.1	9.5	0.70	6.1	7.5	6.8	0.95	4.0
40,	9.4	8.6	0.84	6.0	11.6	10.9	0.80	6.91	8.5	7.8	1.08	4.6
Green fodders.	Barley and peas, 1:2.2.				Red clover (green), 1:[illegible].7				Alsike clover (green), 1:5.3.			
2½,	0.7	0.5	0.07	0.2	0.7	0.7	0.07	0.4	0.6	0.6	0.07	0.3
5,	1.0	0.9	0.14	0.4	1.5	1.4	0.15	0.8	1.3	1.2	0.13	0.7
10,	2.1	1.9	0.28	0.9	2.9	2.7	0.29	1.6	2.5	2.3	0.26	1.4
15,	3.1	2.8	0.42	1.4	4.4	4.0	0.44	2.5	3.8	3.5	0.39	2.1
20,	4.1	3.8	0.56	1.8	5.8	5.4	0.58	3.3	5.0	4.7	0.52	2.8
25,	5.2	4.7	0.70	2.2	7.2	6.8	0.73	4.1	6.3	5.9	0.65	3.5
30,	6.2	5.6	0.84	2.7	8.8	8.2	0.87	4.9	7.6	7.0	0.78	4.2
35,	7.2	6.6	0.98	3.2	10.2	9.7	1.02	5.7	8.8	8.1	0.91	4.9
40,	8.2	7.5	1.12	3.6	11.7	10.9	1.16	6.6	10.1	9.3	1.04	5.6
Green fodders and silages.	Green clover rowen, 1:4.2.				Corn silage (mature), 1:14.8.				Corn silage (immature), 1:14.8.			
2½,	0.6	0.6	0.07	0.3	0.7	0.6	0.03	0.4	0.5	0.5	0.02	0.3
5,	1.3	1.2	0.14	0.6	1.3	1.2	0.06	0.8	1.0	1.0	0.05	0.6
10,	2.7	2.3	0.29	1.2	2.6	2.5	0.12	1.8	2.1	2.0	0.09	1.3
15,	3.8	3.5	0.44	1.8	3.9	3.6	0.18	2.7	3.1	2.9	0.14	1.9
20,	5.0	4.6	0.58	2.4	5.3	4.9	0.24	3.6	4.2	3.9	0.18	2.6
25,	6.3	5.8	0.73	3.0	6.6	6.2	0.30	4.5	5.2	4.9	0.23	3.2
30,	7.7	6.9	0.87	3.6	7.9	7.4	0.36	5.3	6.3	5.9	0.27	3.9
35,	8.8	8.1	1.02	4.2	9.2	8.7	0.42	6.2	7.3	6.8	0.32	4.5
40,	10.0	9.2	1.16	4.8	10.5	9.9	0.48	7.1	8.4	7.8	0.36	5.2

TABLE II.—POUNDS OF TOTAL DRY MATTER, TOTAL ORGANIC MATTER AND DIGESTIBLE INGREDIENTS—Continued.

Pounds of Fodder.	Total dry matter.	Organic matter.	Protein.	Carbohydrates, etc.	Total dry matter.	Organic matter.	Protein.	Carbohydrates, etc.	Total dry matter.	Organic matter.	Protein.	Carbohydrates, etc.
Silages, etc.	Corn stover silage, 1:16.6.				Clover silage, 1:4.7.				Potatoes, 1:17.3.			
2½,	0.5	0.4	0.02	0.3	0.7	0.6	0.07	0.3	0.5	0.5	0.02	0.4
5,	1.0	0.9	0.03	0.5	1.4	1.3	0.14	0.6	1.1	1.0	0.05	0.8
10,	1.9	1.8	0.06	1.0	2.8	2.5	0.27	1.3	2.1	2.0	0.09	1.6
15,	2.9	2.6	0.09	1.5	4.2	3.8	0.41	1.9	3.2	3.0	0.14	2.3
20,	3.9	3.5	0.12	2.0	5.6	5.1	0.54	2.6	4.2	4.0	0.18	3.1
25,	4.8	4.4	0.15	2.5	7.0	6.1	0.68	3.2	5.3	5.0	0.23	3.9
30,	5.8	5.3	0.18	3.0	8.4	7.6	0.81	3.9	6.3	6.0	0.27	4.7
35,	6.8	6.1	0.21	3.5	9.8	8.9	0.95	4.5	7.4	7.0	0.32	5.4
40,	7.7	7.0	0.24	4.0	11.2	10.2	1.08	5.1	8.4	8.0	0.36	6.2
Roots.	Beets, 1:6.5.				Sugar beet, 1:6.8.				Carrots, 1:9.6.			
2½,	0.3	0.3	0.04	0.2	0.3	0.3	0.04	0.3	0.3	0.3	0.03	0.2
5,	0.6	0.5	0.07	0.5	0.7	0.6	0.08	0.5	0.5	0.5	0.05	0.5
10,	1.2	1.1	0.14	0.9	1.4	1.3	0.16	1.1	1.1	1.0	0.10	0.1
15,	1.7	1.6	0.21	1.4	2.0	1.9	0.24	1.7	1.6	1.6	0.15	1.4
20,	2.3	2.1	0.28	1.8	2.7	2.5	0.32	2.2	2.3	2.1	0.20	1.9
25,	2.9	2.6	0.35	2.3	3.4	3.1	0.40	2.7	2.9	2.6	0.25	2.4
30,	3.5	3.1	0.42	2.7	4.1	3.8	0.48	3.3	3.4	3.1	0.30	2.9
35,	4.0	3.7	0.49	3.2	4.7	4.4	0.56	3.8	4.0	3.6	0.35	3.4
40,	4.6	4.2	0.56	3.6	5.4	5.0	0.64	4.4	4.6	4.2	0.40	3.8
Roots.	Mangel wurzels, 1:4.9.				Rutabagas, 1:8.6.				Turnips, 1:7.7.			
2½,	0.2	0.2	0.03	0.1	0.3	0.2	0.03	0.2	0.2	0.2	0.03	0.2
5,	0.4	0.4	0.06	0.3	0.5	0.5	0.05	0.4	0.5	0.4	0.05	0.4
10,	0.9	0.8	0.11	0.5	1.1	1.0	0.10	0.9	1.0	0.9	0.10	0.8
15,	1.4	1.2	0.17	0.8	1.6	1.5	0.15	1.3	1.4	1.3	0.15	1.2
20,	1.8	1.6	0.22	1.1	2.3	2.0	0.20	1.7	1.9	1.7	0.20	1.5
25,	2.3	2.0	0.28	1.4	2.9	2.6	0.25	2.2	2.4	2.2	0.25	1.9
30,	2.7	2.4	0.33	1.6	3.4	3.1	0.30	2.6	2.9	2.6	0.30	2.3
35,	3.2	2.8	0.39	1.9	4.0	3.6	0.35	3.0	3.3	3.0	0.35	2.7
40,	3.6	3.2	0.41	2.2	4.6	4.1	0.40	3.4	3.8	3.5	0.40	3.1

TABLE II.—POUNDS OF TOTAL DRY MATTER, TOTAL ORGANIC MATTER AND DIGESTIBLE INGREDIENTS—Continued.

Pounds of Fodder.	Total dry matter.	Organic matter.	Protein.	Carbohydrates, etc.	Total dry matter.	Organic matter.	Protein.	Carbohydrates, etc.	Total dry matter.	Organic matter.	Protein.	Carbohydrates, etc.
Milk.	Skim milk, 1:2.0.				Buttermilk, 1:1.7.				Whey, 1:8.7.			
2½,	0.2	0.2	0.07	0.1	0.2	0.2	0.10	0.2	0.2	0.1	0.02	0.1
5,	0.5	0.4	0.15	0.3	0.5	0.5	0.19	0.3	0.3	0.3	0.03	0.3
10,	0.9	0.9	0.29	0.6	1.0	0.9	0.38	0.6	0.6	0.6	0.06	0.5
15,	1.4	1.3	0.44	0.9	1.5	1.4	0.57	1.0	0.9	0.8	0.09	0.8
20,	1.9	1.7	0.58	1.2	2.0	1.8	0.76	1.3	1.2	1.2	0.12	1.0
25,	2.4	2.2	0.73	1.6	2.5	2.3	0.95	1.6	1.5	1.5	0.15	1.3
30,	2.8	2.6	0.87	1.8	3.0	2.8	1.14	1.9	1.9	1.8	0.18	1.6
35,	3.2	3.0	1.02	2.1	3.5	3.3	1.33	3.2	2.2	2.0	0.21	1.8
40,	3.7	3.5	1.16	2.4	4.0	3.7	1.52	2.6	2.5	2.3	0.24	2.1
Hays.	Mixed hay, 1:10.0.				Timothy hay, 1:16.5.				Redtop hay, 1:10.3.			
2½,	2.1	2.0	0.11	1.1	2.2	2.1	0.07	1.2	2.3	2.1	0.12	1.2
5,	4.2	4.0	0.22	2.2	4.3	4.1	0.14	2.3	4.6	4.3	0.24	2.4
7½,	6.4	5.9	0.33	3.3	6.5	6.2	0.21	3.5	6.8	6.4	0.36	3.6
10,	8.5	7.9	0.44	4.4	8.7	8.2	0.28	4.6	9.1	8.6	0.48	4.9
12½,	10.6	9.9	0.55	5.5	10.9	10.3	0.35	5.8	11.4	10.7	0.60	6.2
15,	12.7	11.9	0.66	6.6	13.0	12.4	0.42	6.9	13.9	12.9	0.72	7.4
17½,	14.8	13.9	0.77	7.7	15.2	14.2	0.49	8.1	16.0	15.0	0.84	8.6
20,	16.9	15.8	0.88	8.8	17.4	16.5	0.56	9.2	18.2	17.2	0.96	9.8
25,	21.2	19.8	1.10	11.0	21.7	20.6	0.70	11.6	22.8	21.5	1.20	12.3
Hays.	Kentucky blue grass hay, 1:10.6.				Rowen hay (mixed), 1:5.6.				Rowen hay (fine), 1:4.7.			
2½,	1.9	1.7	0.09	1.0	2.1	1.9	0.20	1.1	2.2	2.0	0.24	1.1
5,	3.7	3.4	0.19	2.1	4.2	3.8	0.40	2.3	4.3	4.0	0.49	2.3
7½,	5.6	5.0	0.28	3.0	6.3	5.7	0.60	3.4	6.5	6.0	0.73	3.4
10,	7.4	6.7	0.37	3.9	8.3	7.7	0.80	4.5	8.7	8.0	0.97	4.6
12½,	9.2	8.4	0.46	4.9	10.4	9.5	1.00	5.6	10.9	10.0	1.21	5.7
15,	11.1	10.1	0.56	5.9	12.5	11.4	1.20	6.7	13.0	12.1	1.46	6.8
17½,	13.0	11.7	0.65	6.9	14.6	13.4	1.40	7.8	15.2	14.1	1.70	8.0
20,	14.8	13.4	0.74	7.9	16.7	15.3	1.60	8.9	17.4	16.1	1.94	9.1
25,	18.5	16.8	0.93	9.9	20.9	19.2	2.00	11.2	21.7	20.1	2.43	11.4

TABLE II.—POUNDS OF TOTAL DRY MATTER, TOTAL ORGANIC MATTER AND DIGESTIBLE INGREDIENTS—Continued.

Pounds of Fodder.	Total dry matter.	Organic matter.	Protein.	Carbohydrates, etc.	Total dry matter.	Organic matter.	Protein.	Carbohydrates, etc.	Total dry matter.	Organic matter.	Protein.	Carbohydrates, etc.
Dry fodders.	Corn fodder, 1:14.3.				Corn stover, 1:23.6.				Oat hay, 1:9.9.			
2½,	1.4	1.4	0.06	0.9	1.5	1.4	0.04	0.8	2.3	2.1	0.10	1.0
5,	2.9	2.8	0.13	1.8	3.0	2.8	0.07	1.7	4.6	4.2	0.21	2.0
7½,	4.3	4.1	0.19	2.7	4.5	4.2	0.11	2.5	6.8	6.4	0.31	3.0
10,	5.8	5.5	0.25	3.6	6.0	5.7	0.14	3.3	9.1	8.5	0.41	4.0
12½,	7.2	6.9	0.32	4.5	7.5	8.1	0.18	4.1	11.4	10.6	0.51	5.1
15,	8.7	8.3	0.38	5.4	9.0	8.5	0.21	5.0	13.7	12.7	0.62	6.1
17½,	10.1	9.6	0.44	6.2	10.5	9.9	0.25	5.8	16.0	14.9	0.72	7.1
20,	11.6	11.0	0.50	7.1	12.0	11.3	0.28	6.6	18.2	17.0	0.82	8.1
25,	14.5	13.8	0.63	8.9	15.0	14.1	0.35	8.3	22.2	21.2	1.03	10.2
Hays.	Oat and pea hay, 1:4.1.				Hungarian hay, 1:10.0.				Red clover hay, 1:5.9			
2½,	2.2	2.0	0.28	1.2	2.1	1.9	0.12	1.2	2.1	2.0	0.18	1.0
5,	4.4	4.1	0.56	2.3	4.2	3.9	0.25	2.4	4.2	3.9	0.36	2.1
7½,	6.6	6.1	0.84	3.5	6.3	5.9	0.37	3.6	6.4	5.9	0.53	3.2
10,	8.9	8.2	1.12	4.6	8.4	7.8	0.49	4.9	8.5	7.9	0.71	4.2
12½,	11.1	10.2	1.40	5.8	10.4	9.7	0.62	6.2	10.6	9.8	0.89	5.2
15,	13.3	12.3	1.68	6.9	12.5	11.7	0.74	7.4	12.7	11.8	1.07	6.3
17½,	15.5	14.3	1.96	8.1	14.6	13.6	0.86	8.6	14.8	13.7	1.24	7.3
20,	17.7	16.4	2.24	9.2	16.7	15.6	0.98	9.8	16.9	15.7	1.42	8.3
25,	22.1	20.5	2.80	11.6	20.9	19.5	1.23	12.3	21.2	19.6	1.78	10.5
Hays, etc.	Alsike clover hay, 1:5.5.				Clover rowen hay, 1:4.9.				Barley straw, 1:61.0.			
2½,	2.3	2.1	0.21	1.2	2.3	2.1	0.21	1.0	2.1	2.0	0.02	1.1
5,	4.5	4.1	0.42	2.3	4.6	4.2	0.43	2.1	4.3	4.0	0.04	2.1
7½,	6.8	6.2	0.63	3.5	6.9	6.4	0.64	3.2	6.4	6.0	0.05	3.2
10,	9.0	8.2	0.84	4.6	9.2	8.5	0.85	4.2	8.6	8.0	0.07	4.3
12½,	11.3	10.3	1.05	5.8	11.5	10.6	1.07	5.2	10.7	10.0	0.09	5.3
15,	13.5	12.3	1.26	6.9	13.8	12.7	1.28	6.3	12.9	12.0	0.11	6.4
17½,	15.8	14.3	1.47	8.1	16.0	14.8	1.49	7.3	15.0	14.0	0.12	7.5
20,	18.1	16.4	1.68	9.2	18.3	16.9	1.70	8.3	17.2	16.0	0.14	8.5
25,	22.6	20.5	2.10	11.6	22.9	21.2	2.13	10.5	21.5	20.0	0.19	10.7

TABLE II.—POUNDS OF TOTAL DRY MATTER, TOTAL ORGANIC MATTER AND DIGESTIBLE INGREDIENTS—Continued.

Pounds of Fodder.	Total dry matter.	Organic matter.	Protein.	Carbohydrates, etc.	Total dry matter.	Organic matter.	Protein.	Carbohydrates, etc.	Total dry matter.	Organic matter.	Protein.	Carbohydrates, etc.
Straws.	Oat straw, 1:38.3.				Wheat straw, 1:69.0.				Rye straw, 1:69.0.			
2½,	2.3	2.1	0.03	1.2	2.3	2.1	0.01	0.9	2.3	2.2	0.02	1.0
5,	4.6	4.3	0.06	2.3	4.5	4.3	0.02	1.9	4.6	4.5	0.03	2.1
7½,	6.8	6.4	0.09	3.5	6.8	6.4	0.03	2.8	7.0	6.7	0.05	3.1
10,	9.1	8.6	0.12	4.8	9.0	8.6	0.04	3.7	9.3	9.0	0.06	4.1
12½,	11.4	10.7	0.15	5.8	11.3	10.7	0.05	4.6	11.6	11.2	0.08	5.2
15,	13.9	12.9	0.18	6.9	13.5	12.9	0.06	5.6	13.9	13.4	0.09	6.2
17½,	16.0	15.0	0.21	8.1	15.8	15.0	0.07	6.5	16.3	15.7	0.11	7.2
20,	18.2	17.2	0.24	9.2	18.1	17.2	0.08	7.4	18.7	17.9	0.12	8.3
25,	22.7	21.5	0.30	11.5	22.6	21.6	0.10	9.3	23.2	22.4	0.15	10.4

Pounds of Fodder.	Total dry matter.	Organic matter.	Protein.	Carbohydrates, etc.	Total dry matter.	Organic matter.	Protein.	Carbohydrates, etc.	Total dry matter.	Organic matter.	Protein.	Carbohydrates, etc.
Grains.	Corn meal, 1:11.3.				Corn and cob meal, 1:13.9.				Oats, 1:6.2.			
¼,	0.2	0.2	0.02	0.2	0.2	0.2	0.01	0.2	0.2	0.2	0.02	0.1
½,	0.4	0.4	0.03	0.4	0.4	0.4	0.02	0.3	0.4	0.4	0.05	0.3
1,	0.9	0.8	0.06	0.7	0.9	0.8	0.05	0.7	0.9	0.9	0.09	0.6
2,	1.7	1.7	0.10	1.4	1.7	1.7	0.10	1.3	1.8	1.7	0.18	1.1
3,	2.6	2.5	0.15	2.1	2.6	2.5	0.14	2.0	2.7	2.6	0.28	1.7
4,	3.4	3.3	[illegible]	[illegible]	3.4	3.3	0.19	2.7	3.6	3.4	0.37	2.3
5,	4.3	4.2	[illegible]	3.6	4.3	4.2	0.24	3.4	4.5	4.3	0.46	2.8
7½,	6.4	6.3	[illegible]	5.4	6.4	[illegible]	[illegible]	5.1	6.7	[illegible]	0.69	4.3
10,	8.5	8.4	[illegible]	7.1	8.5	8.4	0.48	6.7	8.9	8.6	0.92	5.7

Pounds of Fodder.	Total dry matter.	Organic matter.	Protein.	Carbohydrates, etc.	Total dry matter.	Organic matter.	Protein.	Carbohydrates, etc.	Total dry matter.	Organic matter.	Protein.	Carbohydrates, etc.
Grains, etc.	Provender (½ ½), 1:8.4.				Provender (as sold in New England), 1:9.4.				Oat hulls, 1:18.2.			
¼,	0.2	0.2	0.02	0.2	0.2	0.2	0.02	0.2	0.2	0.2	0.01	0.1
½,	0.4	0.4	[illegible]	0.3	0.4	0.4	0.13	[illegible]	0.5	0.4	0.02	0.3
1,	0.9	0.9	[illegible]	0.6	[illegible]	0.9	[illegible]	[illegible]	0.9	0.9	0.03	0.5
2,	1.7	1.7	[illegible]	1.3	1.8	1.7	[illegible]	1.3	1.9	1.7	[illegible]	0.9
3,	2.6	2.6	[illegible]	1.9	2.7	2.6	[illegible]	[illegible]	2.8	2.6	[illegible]	1.4
4,	3.5	3.4	0.31	2.6	[illegible]	3.4	0.27	[illegible]	3.7	3.4	[illegible]	1.9
5,	4.4	4.3	[illegible]	3.2	[illegible]	4.3	[illegible]	[illegible]	4.6	[illegible]	0.13	2.4
7½,	6.5	6.4	[illegible]	4.9	[illegible]	6.5	[illegible]	[illegible]	7.0	6.5	[illegible]	3.5
10,	8.7	8.5	[illegible]	6.5	[illegible]	8.8	[illegible]	[illegible]	9.3	8.6	[illegible]	4.7

TABLE II.—POUNDS OF TOTAL DRY MATTER, TOTAL ORGANIC MATTER AND DIGESTIBLE INGREDIENTS—Continued.

Pounds of Fodder.	Total dry matter.	Organic matter.	Protein.	Carbohydrates, etc.	Total dry matter.	Organic matter.	Protein.	Carbohydrates, etc.	Total dry matter.	Organic matter.	Protein.	Carbohydrates, etc.
By-products, etc.	Quaker dairy feed, 1:4.6.				H. O. dairy feed, 1:3.3.				Victor corn and oat feed, 1:10.1.			
¼,	0.2	0.2	0.03	0.1	0.2	0.2	0.04	0.1	0.2	0.2	0.02	0.2
½,	0.5	0.4	0.05	0.3	0.5	0.4	0.07	0.2	0.5	0.4	0.03	0.3
1,	0.9	0.9	0.11	0.5	0.9	0.9	0.15	0.5	0.9	0.9	0.06	0.6
2,	1.8	1.7	0.22	1.0	1.8	1.7	0.29	1.0	1.8	1.7	0.13	1.3
3,	2.8	2.6	0.33	1.5	2.7	2.6	0.44	1.5	2.7	2.6	0.19	1.9
4,	3.7	3.5	0.44	2.0	3.6	3.5	0.59	2.0	3.6	3.4	0.25	2.5
5,	4.6	4.4	0.55	2.5	4.6	4.4	0.74	2.5	4.5	4.3	0.32	3.2
7½,	6.9	6.5	0.82	3.8	6.8	6.5	1.10	3.7	6.8	6.5	0.47	4.8
10,	9.2	8.7	1.09	5.0	9.1	8.7	1.47	4.9	9.0	8.6	0.63	6.4
By-products, etc.	H. O. horse feed, 1:6.4.				Barley, 1:8.0.				Barley screenings, 1:7.7.			
¼,	0.2	0.2	0.02	0.1	0.2	0.2	0.02	0.2	0.2	0.2	0.02	0.2
½,	0.5	0.5	0.05	0.3	0.4	0.4	0.0	0.3	0.4	0.4	0.04	0.3
1,	0.9	0.9	0.09	0.6	0.9	0.9	0.09	0.7	0.9	0.8	0.09	0.7
2,	1.8	1.7	0.18	1.2	1.8	1.7	0.17	1.4	1.8	1.7	0.17	1.3
3,	2.7	2.6	0.28	1.8	2.7	2.6	0.26	2.1	2.6	2.5	0.26	2.0
4,	3.6	3.5	0.37	2.4	3.6	3.5	0.35	2.8	3.5	3.4	0.34	2.7
5,	4.5	4.4	0.46	2.9	4.5	4.4	0.44	3.5	4.4	4.2	0.43	3.3
7½,	6.8	6.5	0.69	4.4	6.7	6.5	0.65	5.2	6.6	6.3	0.65	6.0
10,	9.0	8.7	0.92	5.9	8.9	8.7	0.87	6.9	8.8	8.4	0.86	6.6
By-products.	Wheat bran, 1:3.8.				Wheat middlings, 1:4.6.				Wheat screenings, 1:5.2.			
¼,	0.2	0.2	0.03	0.1	0.2	0.2	0.03	0.1	0.2	0.2	0.02	0.1
½,	0.4	0.4	0.06	0.2	0.4	0.4	0.06	0.3	0.4	0.4	0.05	0.2
1,	0.9	0.8	0.12	0.5	0.9	0.9	0.13	0.6	0.9	0.9	0.10	0.5
2,	1.8	1.6	0.24	1.0	1.8	1.7	0.25	1.2	1.8	1.7	0.20	1.0
3,	2.6	2.5	0.36	1.4	2.6	2.6	0.38	1.7	2.7	2.6	0.29	1.5
4,	3.5	3.3	0.48	1.8	3.5	3.4	0.50	2.3	3.5	3.4	0.39	2.0
5,	4.4	4.1	0.60	2.3	4.4	4.3	0.63	2.9	4.4	4.3	0.49	2.5
7½,	6.6	6.2	0.90	3.4	6.6	6.4	0.94	4.4	6.6	6.5	0.74	3.8
10,	8.8	8.2	1.20	4.6	8.8	8.6	1.25	5.8	8.8	8.6	0.98	5.1

TABLE II.—POUNDS OF TOTAL DRY MATTER, TOTAL ORGANIC MATTER AND DIGESTIBLE INGREDIENTS—Continued.

Pounds of Fodder.	Total dry matter.	Organic matter.	Protein.	Carbohydrates, etc.	Total dry matter.	Organic matter.	Protein.	Carbohydrates, etc.	Total dry matter.	Organic matter.	Protein.	Carbohydrates, etc.
By-products.	Mixed (wheat) feed, 1:3.9.				Red-dog flour, 1:3.3.				Rye, 1:7.8.			
¼,	0.2	0.2	0.03	0.1	0.2	0.2	0.04	0.1	0.2	0.2	0.02	0.2
½,	0.4	0.4	0.07	0.3	0.5	0.4	0.09	0.3	0.4	0.4	00.4	0.3
1,	0.9	0.8	0.13	0.5	0.9	0.9	0.18	0.6	0.9	0.9	0.09	0.7
2,	1.8	1.7	0.27	1.0	1.8	1.7	0.36	1.2	1.8	1.7	0.18	1.4
3,	2.7	2.5	0.40	1.5	2.7	2.6	0.53	1.7	2.7	2.6	0.27	2.1
4,	3.6	3.3	0.53	2.1	3.6	3.5	0.71	2.3	3.5	3.5	0.36	2.8
5,	4.5	4.3	0.67	2.6	4.6	4.4	0.89	2.9	4.4	4.4	0.46	3.5
7½,	6.7	6.3	1.00	3.8	6.8	6.5	1.34	4.4	6.6	6.5	0.67	5.2
10,	8.9	8.4	1.33	5.2	9.1	8.7	1.78	5.8	8.8	8.7	0.89	6.9
By-products.	Rye bran, 1:5.1.				Cottonseed meal, 1:1.0.				Cottonseed feed, 1:5.6.			
¼,	0.2	0.2	0.03	0.2	0.2	0.2	0.10	0.1	0.2	0.2	0.02	0.1
½,	0.4	0.4	0.06	0.3	0.5	0.4	0.20	0.2	0.4	0.4	00.4	0.2
1,	0.9	0.9	0.12	0.6	0.9	0.9	0.40	0.4	0.9	0.9	0.08	0.4
2,	1.8	1.7	0.25	1.3	1.8	1.7	0.80	0.8	1.8	1.1	0.16	0.9
3,	2.7	2.6	0.37	1.9	2.8	2.6	1.20	1.2	2.7	2.6	0.25	1.3
4,	3.5	3.4	0.49	2.5	3.7	3.4	1.60	1.6	3.5	3.4	0.32	1.8
5,	4.4	4.3	0.62	3.1	4.6	4.3	2.00	2.0	4.4	4.3	0.40	2.2
7½,	6.6	6.4	0.92	4.7	6.9	6.4	3.00	3.0	6.6	6.4	0.59	3.3
10,	8.8	8.5	1.23	6.3	9.2	8.5	4.00	4.0	8.8	8.5	0.79	4.4
By-products.	Cottonseed hulls.				Linseed meal (O. P.), 1:1.5.				Linseed meal (N. P.), 1:1.3.			
¼,	0.2	0.2	......	0.1	0.2	0.2	0.08	0.1	0.2	0.2	0.08	0.1
½,	0.4	0.4	......	0.2	0.5	0.4	0.15	0.2	0.4	0.4	0.16	0.2
1,	0.9	0.9	......	0.4	0.9	0.8	0.31	0.5	0.9	0.8	0.32	0.4
2,	1.8	1.7	......	0.7	1.8	1.7	0.62	1.0	1.8	1.7	0.65	0.8
3,	2.7	2.6	......	1.1	2.7	2.5	0.92	1.4	2.7	2.5	0.97	1.2
4,	3.6	3.4	......	1.5	3.6	3.4	1.23	1.8	3.6	3.4	1.30	1.7
5,	4.5	4.3	......	1.8	4.9	4.2	1.54	2.3	4.5	4.2	1.62	2.1
7½,	6.7	6.5	......	2.7	6.8	6.3	2.31	3.4	6.7	6.3	2.43	3.2
10,	8.9	8.6	......	3.7	9.0	8.4	3.08	4.6	8.9	8.4	3.25	4.2

TABLE II. POUNDS OF TOTAL DRY MATTER, TOTAL ORGANIC MATTER AND DIGESTIBLE INGREDIENTS—Continued.

Pounds of Fodder.	Total dry matter.	Organic matter.	Protein.	Carbohydrates, etc.	Total dry matter.	Organic matter.	Protein.	Carbohydrates, etc.	Total dry matter.	Organic matter.	Protein.	Carbohydrates, etc.
By-products.	Flax meal, 1:1.4.				Gluten meal (Chicago), 1:1.5.				Gluten meal (Cream),			
1/4,	0.2	0.2	0.08	0.2	0.2	0.2	0.08	0.1	0.2	0.2	0.07	0.1
1/2,	0.4	0.4	0.16	0.2	0.4	0.4	0.16	0.2	0.4	0.4	0.15	0.2
1,	0.9	0.8	0.32	0.4	0.9	0.9	0.32	0.5	0.9	0.9	0.39	0.5
2,	1.8	1.7	0.64	0.9	1.8	1.7	0.64	0.9	1.8	1.8	0.59	1.0
3,	2.7	2.5	0.96	1.3	2.6	2.6	0.96	1.4	2.7	2.7	0.89	1.5
4,	3.6	3.4	1.28	1.7	3.5	3.4	1.28	1.9	3.6	3.6	1.19	2.1
5,	4.5	4.2	1.60	2.2	4.4	4.3	1.60	2.3	4.5	4.5	1.49	2.6
7 1/2,	6.7	6.3	2.40	3.3	6.6	6.5	2.40	3.5	6.7	6.7	2.43	3.9
10,	8.9	8.4	3.21	4.3	8.8	8.6	3.21	4.7	9.0	8.9	2.97	5.2
By-products.	Gluten meal (King), 1:1.9.				Gluten feed (Buffalo or Marshalltown), 1:2.4.				Gluten feed (Diamond or Rockford), 1:3.0.			
1/4,	0.2	0.2	0.07	0.1	0.2	0.2	0.06	0.1	0.2	0.2	0.05	0.2
1/2,	0.5	0.5	0.17	0.3	0.4	0.4	0.12	1.2	0.5	0.4	0.10	0.3
1,	0.9	0.9	0.34	0.6	0.9	0.9	0.23	0.6	0.9	0.9	0.20	0.6
2,	1.9	1.7	0.68	1.1	1.8	1.8	0.47	1.1	1.8	1.8	0.41	1.2
3,	2.8	1.8	0.89	1.7	2.7	2.6	0.70	1.7	2.7	2.7	0.61	1.9
4,	3.7	3.7	1.19	2.3	3.6	3.5	0.93	2.3	3.6	3.6	0.81	2.5
5,	4.6	4.6	1.49	2.8	4.5	4.4	1.17	2.8	4.6	4.5	1.02	3.1
7 1/2,	6.9	6.9	2.23	4.3	6.8	6.6	1.75	4.2	6.8	6.8	1.52	4.7
10,	9.3	9.2	2.97	5.7	9.0	8.8	2.33	5.7	9.1	9.0	2.03	6.2
By-products.	Hominy chop, 1:9.2.				Starch feed, wet, 1:4.9.				Dried brewers' grains, 1:3.0.			
1/4,	0.2	0.2	0.02	0.2	0.1	0.1	0.01	0.1	0.2	0.2	0.04	0.1
1/2,	0.5	0.4	0.04	0.4	0.2	0.2	0.03	0.2	0.5	0.4	0.08	0.3
1,	0.9	0.9	0.09	0.8	0.3	0.3	0.05	0.3	0.9	0.9	0.16	0.5
2,	1.8	1.8	0.17	1.6	0.7	0.6	0.11	0.5	1.8	1.8	0.31	0.9
3,	2.8	2.7	0.26	2.4	1.0	1.0	0.16	0.8	2.8	2.6	0.47	1.4
4,	3.7	3.6	0.35	3.2	1.4	1.4	0.22	1.1	3.7	3.5	0.63	1.3
5,	4.6	4.5	0.44	4.0	1.7	1.7	0.27	1.3	4.6	4.4	0.79	2.4
7 1/2,	6.9	6.7	0.65	6.0	2.6	2.6	0.41	1.7	6.9	6.6	1.18	3.5
10,	9.2	8.9	0.87	8.0	3.5	3.4	0.54	2.6	9.2	8.8	1.57	4.7

TABLE II.—POUNDS OF TOTAL DRY MATTER, TOTAL ORGANIC MATTER AND DIGESTIBLE INGREDIENTS—Continued.

Pounds of Fodder.	Total dry matter.	Organic matter.	Protein.	Carbohydrates, etc.	Total dry matter.	Organic matter.	Protein.	Carbohydrates, etc.	Total dry matter.	Organic matter.	Protein.	Carbohydrates, etc.
By-products.	Atlas gluten meal, 1:2.6				Malt sprouts, 1:2.2.				Pea meal, 1:3.2.			
¼,	0.2	0.2	0.06	0.2	0.2	0.2	0.05	0.1	0.2	0.2	0.04	0.1
½,	0.5	0.4	0.12	0.3	0.4	0.4	0.09	0.2	0.4	0.4	0.08	0.3
1,	0.9	0.9	0.25	0.6	0.9	0.8	0.19	0.4	0.9	0.9	0.17	0.5
2,	1.8	1.8	0.49	1.3	1.8	1.7	0.37	0.8	1.8	1.7	0.33	1.1
3,	2.8	2.7	0.74	1.9	2.7	2.5	0.56	1.2	2.7	2.6	0.50	1.6
4,	3.7	3.6	0.98	2.6	3.6	3.3	0.74	1.6	3.6	3.5	0.67	2.1
5,	4.6	4.5	1.23	3.2	4.5	4.2	0.93	2.0	4.5	4.4	0.84	2.7
7½,	6.9	6.7	1.85	4.9	6.7	6.3	1.40	3.0	6.7	6.5	1.26	4.0
10,	9.2	9.0	2.46	6.5	9.0	8.4	1.86	4.0	9.0	8.7	1.68	5.3

AVERAGE COMPOSITION OF FEEDING STUFFS.

Taken from Bulletin No. 16, Prepared by Enos H. Hess, of the State Experiment Station, State College, Pa.

The following table is taken from "Rational Stock Feeding," by H. P. Armsby, with a few additions from the New Jersey report of 1894:

"The figures for the percentage composition are taken, in nearly every case, from the compilations of analysis of American feeding stuffs, prepared by Drs. Jenkins and Winton, of the Connecticut Station, for the Office of Experiment Stations of the United States Department of Agriculture. The figures for the percentages of digestible matter, contained in the last five columns of the table, have been calculated from the average results of American digestion experiments, as compiled by Director Jordan of the Maine Station for the Office of Experiment Stations. In those cases in which no American results were available, the average results of German digestion experiments have been used, and in cases where no results were available the digestibility has been estimated from that of other feeding stuffs of similar composition and properties. These latter cases are distinguished by being closed in parenthesis in the table.

"Under percentages of digestible matter are given, first, the percentages of digestible protein, carbohydrates and fat; second, in the column headed 'total,' the percentage of total digestible matter reduced to its 'starch equivalent.' A pound of fat has been shown to be about two and one-fourth times as valuable as a pound of carbohydrates for the production of heat or force in the body; consequently the percentage of fat has been multiplied by two and one-fourth and the percentages of carbohydrates and protein added to give the figures under the heading 'total' in the next to the last column of the table. By the nutritive ratio of a feeding stuff is meant the ratio of digestible protein to other digestible matter, the latter having been reduced to its starch equivalent. Thus, the first feeding stuff given in the table contains 1.1 per cent. of digestible protein and 12.3 per cent. of total digestible matter calculated to its starch equivalent. Subtracting the 1.1 per cent. of protein, we have left 11.2 per cent. of other digestible matters, consequently, the ratio of digestible protein to other digestible matters is 1.1:11.2, or 1:10.2, as given in the last column of the table.

Average Composition of Feeding Stuffs.

	Percentage Composition.							Per Cent. of Digestible Matter.				
	Number of analyses.	Water.	Ash.	Protein.	Crude fibre.	Nitrogen-free extract.	Fat.	Protein.	Carbohydrates.	Fat.	Total.†	Nutritive ratio.
Soiling Fodder.												
Corn—dent, cut before glasing,	54	79.7	1.2	1.7	5.4	4.5	0.5	1.6	11.8	0.4	13.8	1:11.5
Cow pea,	10	83.6	1.7	2.4	4.8	7.1	0.4	1.6	7.0	0.2	9.1	1: 4.7
Crimson clover (just heading),*	2	89.2	1.2	2.5	1.8	4.9	0.4	1.7	4.4	0.2	6.6	1: 2.9
Crimson clover (full bloom),*	6	81.5	1.5	3.2	5.1	8.1	0.6	2.2	8.2	0.3	11.1	1: 4.1
Oats,	5	62.2	2.5	3.4	11.2	19.3	1.4	(2.7)	(22.3)	(1.0)	(27.3)	(1: 9.1)
Orchard grass in bloom,*	4	73.0	2.0	2.6	8.2	13.3	0.9	1.8	15.5	0.6	18.7	1: 9.4
Pasture grass,*	17	70.3	2.8	4.7	6.5	14.5	1.2	3.5	16.2	0.8	21.5	1: 5.2
Red clover,	43	70.8	2.1	4.4	8.1	13.5	1.1	3.0	13.3	0.7	17.9	1: 5.0
Rye,	6	82.0	1.6	2.4	4.8	8.5	0.7	1.9	9.8	0.5	12.8	1: 5.7
Soja bean,	6	74.8	2.4	3.0	7.3	11.5	1.0	(2.3)	(10.0)	(0.7)	(13.9)	(1: 5.0)
Silage.												
Corn silage—kernels glazing or more mature,	14	72.1	1.4	2.1	6.7	16.4	1.3	1.1	15.7	1.1	19.3	1:16.5
Red clover,	5	72.0	2.6	4.2	8.4	11.6	1.2	(2.8)	(3.5)	(0.8)	(18.1)	(1: 5.5)
Hay, Straw, Etc.												
Alfalfa hay,	21	8.4	7.4	14.3	25.0	42.7	2.2	10.4	40.5	1.1	53.4	1: 4.1
Corn fodder—field cured,	35	42.2	2.7	4.5	14.3	34.7	1.6	2.5	33.4	1.2	38.6	1:14.4
Corn stover*—field cured,	60	40.1	3.4	3.8	19.7	31.9	1.1	2.0	33.4	0.6	36.8	1:17.4
Clover hay—red,	38	15.3	6.2	12.3	24.8	38.1	3.3	6.4	34.9	1.6	44.9	1: 6.0
Hungarian grass, hay,*	12	7.7	6.0	7.5	27.7	40.0	2.1	4.2	46.7	1.0	53.2	1:11.4
Mixed meadow grass hay,*	11	16.0	4.6	6.4	29.9	41.0	2.1	3.6	42.9	1.0	48.8	1:12.6
Mixed hay,	....	14.3	5.3	9.1	26.9	41.5	2.9	4.7	39.3	1.5	47.4	1: 9.1
Oat straw,	12	9.2	5.1	4.0	37.0	42.4	2.3	1.4	43.9	0.9	47.3	1:32.8
Orchard grass hay,	10	9.9	6.0	8.1	32.4	41.0	2.6	4.8	42.0	1.4	50.0	1: 9.4
Redtop hay,	9	8.9	5.2	7.9	28.6	47.5	1.9	4.8	46.9	1.0	54.0	1:10.3
Rye straw,	7	7.1	3.2	3.0	38.9	46.6	1.2	0.6	40.6	0.4	43.1	1:69.2
Timothy hay,	68	13.2	4.4	5.9	29.0	45.0	2.5	2.9	43.7	1.4	49.8	1:16.2
Wheat straw,	7	9.6	4.2	3.4	38.1	43.4	1.3	0.6	38.2	0.5	39.9	1:65.5
Roots and Tubers.												
Carrots,	8	88.6	1.0	1.1	1.3	7.6	0.4	(0.9)	(8.2)	(0.3)	(9.8)	(1: 9.9)
Mangel wurzels,	9	90.9	1.1	1.4	0.9	5.5	0.2	1.1	5.4	....	6.5	1: 4.9
Potatoes,	12	78.9	1.0	2.1	0.6	17.3	0.1	0.9	15.7	....	16.6	1:17.4
Rutabagas,	4	88.6	1.2	1.2	1.3	7.5	0.2	1.0	8.1	0.2	9.5	1: 8.5
Sugar beets,	19	86.5	0.9	1.8	0.9	9.8	0.1	1.6	10.7	0.1	12.5	1: 6.8
Turnips,	3	90.5	0.8	1.1	1.2	6.2	0.2	1.0	7.2	0.2	8.7	1: 7.7
Grain.												
Barley,	10	10.9	2.4	12.4	2.7	69.8	1.8	8.7	65.6	1.6	77.9	1: 8.6
Buckwheat,	8	12.6	2.0	10.0	8.7	64.5	2.2	(7.8)	(50.7)	(1.8)	(62.6)	(1: 7.0)
Corn—dent,	86	10.6	1.5	10.3	2.2	70.4	5.0	6.2	64.8	4.6	81.4	1:12.1
Corn—flint,	68	11.3	1.4	10.5	1.7	70.1	5.0	6.3	54.5	4.6	81.2	1:11.9
Corn—sweet,	26	8.8	1.9	11.6	2.8	66.8	8.1	7.0	61.5	7.5	85.4	1:11.2
Oats,	30	11.0	3.0	11.8	9.5	59.7	5.0	9.2	47.3	2.6	62.4	1: 5.8
Peas,	......	14.4	2.7	22.6	5.4	53.0	1.9	18.8	51.2	1.0	72.3	1: 2.8
Rye,	6	11.6	1.9	10.6	1.7	72.5	1.7	(6.4)	(66.7)	(1.6)	(76.7)	(1:11.0)
Sorghum seed,	10	12.7	2.1	9.0	2.6	70.0	3.6	(5.4)	(64.4)	(3.3)	(72.2)	(1:13.3)
Wheat—spring,	13	10.4	1.9	12.5	1.8	71.2	2.2	(7.5)	(65.5)	(2.0)	(77.5)	(1: 9.3)
Wheat—winter,	262	10.5	1.8	11.8	1.8	72.0	2.1	(7.1)	(66.2)	(1.9)	(77.6)	(1: 9.9)
Wheat — winter raised in Pennsylvania,	41	10.7	1.6	11.8	1.7	72.2	2.0	(7.1)	(66.4)	(1.8)	(77.6)	1: 9.9
Mill Products.												
Barley meal,	3	11.9	2.6	10.5	6.5	66.3	2.2	7.4	64.3	2.0	76.2	1: 9.3
Corn meal,	77	15.0	1.4	9.2	1.9	68.7	3.8	5.5	63.2	3.5	76.6	1:12.9
Corn-and-cob meal,	7	15.1	1.5	8.5	6.6	64.8	3.5	4.4	60.0	2.9	70.9	1:15.1
Pea meal,	2	10.5	2.6	20.2	14.4	51.1	1.2	16.8	51.7	0.6	69.9	1: 3.2
Rye bran,	7	11.6	3.6	14.7	3.5	63.8	2.8	(11.5)	(44.3)	(2.0)	(60.3)	(1: 4.2)
Wheat bran,	88	11.9	5.8	15.4	9.0	53.9	4.0	12.0	38.9	2.9	57.4	1: 3.8
Wheat middlings,	32	12.1	3.3	15.6	4.6	60.4	4.0	12.8	53.2	3.4	73.7	1: 4.8
Wheat shorts,	12	11.8	4.6	14.9	7.4	56.8	4.5	12.2	50.0	3.8	70.8	1: 4.8

Average Composition of Feeding Stuffs—Continued.

	Number of analyses.	Percentage Composition. Water.	Ash.	Protein.	Crude fibre.	Nitrogen-free extract.	Fat.	Per Cent. of Digestible Matter. Protein.	Carbohydrates.	Fat.	Total.†	Nutritive ratio.
By-Product and Waste Material.												
Apple pomace, ...	7	76.7	0.5	1.4	3.9	16.2	1.3	(1.1)	(16.4)	....	(17.5)	(1:14.9)
Brewers' grains—dried, ...	3	8.2	3.6	19.9	11.0	51.7	5.6	15.7	36.3	5.1	63.5	1: 3.0
Brewers' grains—wet, ...	15	75.7	1.6	5.4	3.8	12.5	1.6	4.3	9.4	1.5	17.1	1: 3.0
Buckwheat middlings, ...	3	13.2	4.8	28.9	4.0	42.0	7.1	(23.7)	(37.0)	(6.0)	(74.2)	(1: 2.1)
Cerealine food,* ...	3	6.9	2.6	10.6	6.8	62.3	8.1	9.0	53.4	6.6	77.3	1: 7.8
Corn oil meal, ...	3	9.0	2.4	24.8	6.7	43.6	13.5	21.1	38.2	10.9	83.8	1: 3.1
Corn cobs, ...	18	10.7	1.4	2.4	30.1	54.9	0.5	0.4	52.5	0.3	53.6	1:33.0
Cotton seed hulls, .	4	10.4	2.6	4.0	44.4	36.6	2.0	0.4	31.5	1.5	35.3	1:87.3
Cotton seed meal,..	35	8.2	7.2	42.3	5.6	23.6	13.1	37.2	15.1	12.7	80.9	1: 1.2
Gluten meal, ...	32	9.6	0.7	29.4	1.6	52.4	6.3	25.6	47.7	5.5	85.7	1: 2.4
Buffalo gluten meal, ...	1	7.8	1.0	21.8	6.7	52.7	10.0	18.5	45.6	8.1	82.3	1: 3.4
Chicago gluten meal, ...	1	11.1	1.2	35.1	0.7	45.0	6.9	30.5	41.0	6.1	85.2	1: 1.8
Cream gluten meal,	1	8.1	1.2	38.4	3.3	32.8	16.2	33.4	29.8	14.8	95.4	1: 1.9
Grano gluten feed,*	3	6.0	2.7	31.0	11.4	34.7	14.2	26.4	33.0	11.5	85.3	1: 2.3
Germ meal,*	1	29.6	11.1	21.7	2.9	45.8	29.6	(13.0)	(43.8)	(26.7)	(116.9)	....
Linseed meal—new process, ...	14	10.1	5.8	33.2	9.5	38.4	3.0	28.9	38.8	2.7	73.8	1: 1.6
Linseed meal—old process, ...	21	9.2	5.7	32.9	8.9	35.4	7.9	29.3	32.7	7.0	77.8	1: 1.7
Malt sprouts, ...:	4	10.2	5.7	23.2	10.7	48.5	1.7	18.6	36.5	1.7	58.9	1: 2.2
Dairy Products,												
Buttermilk, ...	24	91.8	0.8	2.8	......	4.3	0.3	2.8	4.3	0.3	7.8	1: 1.8
Milk, ...	......	87.3	0.7	3.1	......	5.1	3.8	3.1	5.1	3.8	16.8	1: 4.4
Skim milk, ...	303	90.5	0.8	3.5	......	4.8	0.4	3.5	4.8	0.4	9.2	1: 1.6
Whey, ...	......	93.0	0.8	0.8	......	5.0	0.4	0.8	5.0	0.4	6.7	1: 7.4

†The fat reduced to its starch equivalent by multiplying by 2.25.
*Taken from the New Jersey report for 1894.

HOW TO COMPUTE A RATION.

The method of computing a ration is very simple if one knows how to do it, but "know how" is often very difficult to learn. It will be explained in as simple terms as possible in order that all who read carefully may learn how.

We will take a ration that contains 45 pounds ensilage, 5 pounds clover hay and 6 pounds buckwheat middlings. By referring to the table showing the composition of feeding stuffs, we find that these three foods contain the following amounts of digestible matter:

	Total dry matter.	Present Digestible Matter. Protein.	Carbhydrates.	Fat.	Nutritive ratio.
Ensilage—kernels glazed or more matured, ...	27.9	1.1	15.7	1.1	1:16.5
Clover hay—red, ...	84.7	6.4	34.9	1.6	1: 6.0
Buckwheat middlings, ...	86.8	(23.7)	(37.0)	(6.0)	(1: 2.1)

There is 72.1 per cent. of water in ensilage; to determine the amount of dry matter we subtract the amount of water it contains from 100, which leaves us 27.9 per cent. of dry matter. (See table.) The dry matter is obtained in this way for clover hay and buckwheat middlings or any other food you may wish to compute the analysis of.

The figures in the above table give the amount of digestible food in one pound of the different materials. In 45 pounds of ensilage there would be 45 times as much; in 5 pounds of clover hay there would be 5 times as much; and in 6 pounds of buckwheat middlings there would be 6 times as much digestible food as is given in the table. Multiplying these figures by 45, 5 and 6 respectively, we get the following:

	Fresh weight.	Total dry matter.	Protein.	Carbhydrates.	Fat.	Total digestible matter.	Nutritive ratio.
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.		
Ensilage,	45	12.56	.50	7.08	.50	8.08	....
Clover hay,	5	4.24	.32	1.75	.08	2.15	....
Buckwheat middlings,	6	5.21	1.42	2.22	.36	4.00	....
Total,	....	22.01	2.24	11.05	.94	14.23	1: 5.9
Reduced for a cow weighing, 1,000 pounds,	....	22.69	2.31	11.39	.97	14.23	1: 5.9
Wolff's German standard,	....	24.00	2.50	12.50	.40	15.40	1: 5.40

The cows receiving this ration are assumed to weight 970 pounds. Other things being equal, the heavier the cow the more food she will need. The standard ration gives the amount of food required for a cow weighing 1,000 pounds. Therefore, in order to compare this ration with the standard it has to be reduced by dividing by .970. This quotient gives the amount of digestible food that would be required for a cow weighing 1,000 pounds on the same basis. It will be seen that it does not contain as much total dry matter, protein, carbohydrates and total digestible matter as the German standard; but more fat and the nutritive ratio is wider.

HOW TO CALCULATE THE NUTRITIVE RATIO AND TOTAL DIGESTIBLE MATTER.

If we burn a pound of coal we know that there is a certain amount of heat produced. If this heat be applied to water there will be a given quantity of the water converted into steam. Compress this steam and we get power by which we can run a threshing machine or lift a weight.

If we burn protein, carbohydrates or fat we will also get a certain amount of power if the heat is applied to water. We will assume that the burning of one pound of protein will produce enough power to lift one pound one foot from the ground. The carbohydrates have about the same power; but the power produced by burning one pound of fat is two and one-fourth times as great. That is to say, on the same basis, we multiply the amount of fat by two and one-

fourth feet from the ground or two and one-fourth pounds one foot from the ground. In order to have the protein, carbohydrates and fat, if one pound of fat were burned it would lift one pound two and one-fourth feet, and add this product to the amount of carbohydrates and divide the sum obtained, by the protein. The quotient will be the ratio. In the above ration there is .94 pound of fat. This multiplied by $2\frac{1}{4}$ equals 2.12 pounds; add to this amount the 11.05 pounds of carbohydrates and we have 13.17 pounds. Divide this amount by 2.24 (the amount of protein), and we get a quotient of 5.9, which equals the ratio of 1:5.9. That is to say, there is one pound of protein or milk and muscle forming food to 5.9 pounds of carbohydrates and fat or heat and fat forming foods.

AVERAGE PENNSYLVANIA PRICES FOR FEEDING STUFFS.

In a subjoined table is given as near as possible the average selling price of the different feeding stuffs for the past ten years. It was next to impossible to get figures for so long a time on some of the feeds. In these cases the present prices were taken. The cost of all the rations are based on the figures given in this table. In the case of hay, corn stover and other products of the farm the prices given are somewhat below the market price, and in the case of the by-products that have to be bought, the prices are slightly higher than the market price. This was done in order to make allowance for the expense of hauling to or from the farm:

	Price per Ton.	Price per Lb.
Barley meal,	$20 00	1.0
Brewers' grains (dry),	14 00	0.7
Buckwheat meal,	20 00	1.0
Buckwheat middlings,	18 00	.9
Clover hay,	9 00	0.45
Cerealine food,	12 00	.6
Corn-and-cob meal,	15 00	9 75
Corn meal,	19 00	0.95
Corn silage,	2 00	.1
Corn stover,	5 00	0.25
Cotton seed meal,	26 00	1.3
Gluten meal,	18 00	.9
Gluten meal,	18 00	0.90
Gluten meal (Buffalo),	18 00	.9
Gluten meal (Atlas),	18 00	.9
Green rye,	2 00	.1
Hominy meal,	14 00	.7
Linseed meal,	26 00	1.3
Malt sprouts,	22 00	1.1
Mangolds,	2 00	.1
Meadow hay,	11 00	0.55
Millet hay,	8 00	.4
Mixed hay,	10 00	.5
Oat meal,	22 00	1.1
Oat straw,	5 00	0.25
Potatoes,	5 00	0.25
Rutabagas,	3 00	0.15
Skimmed milk,	3 60	0.18
Timothy hay,	11 00	0.55
Wheat bran,	18 00	.9
Wheat chaff,	5 00	0.25
Wheat middlings,	19 00	0.95
Wheat shorts,	19 00	0.95
Wheat straw,	5 00	0.25

FEEDING STANDARDS.

From Bulletin No. 22, Department of Agriculture, Washington, D. C.

Attempts have been made to ascertain the food requirements of various kinds of farm animals under different conditions. Large numbers of feedings experiments have been made under varying conditions with this end in view. From the results, feeding standards have been worked out which show the amounts of digestible protein, fat, and carbohydrates supposed to be best adapted to different animals when kept for different purposes. The feeding standards of Wolff, a German, have been most widely used. They are as follows:

Wolff's Feeding Standards.

A.—Per Day and Per 1,000 Pounds Live Weight.

	Fuel value.	Digestible Food Materials.			Total organic matter.
		Protein.	Carbohydrates.	Fat.	
	Pounds.	Pounds.	Pounds.	Pounds.	Calories.
Oxen at rest in stall,	17.5	0.7	8.0	0.15	16,815
Wool sheep, coarser breeds,	20.0	1.2	10.3	0.20	22,235
Wool sheep, finer breeds,	22.5	1.5	11.4	0.25	25,050
Oxen moderately worked,	24.0	1.6	11.3	0.30	24,260
Oxen heavily worked,	26.0	2.4	13.2	0.50	31,126
Horses moderately worked,	22.5	1.8	11.2	0.60	26,712
Horses heavily worked,	25.5	2.8	13.4	0.80	33,508
Milch cows,	24.0	2.5	12.5	0.40	29,590
Fattening steers:					
First period,	27.0	2.5	15.0	0.50	34,660
Second period,	26.0	3.0	14.8	0.70	36,062
Third period,	25.0	2.7	14.8	0.60	35,082
Fattening sheep:					
First period,	26.0	3.0	15.2	0.50	35,962
Second period,	25.0	3.5	14.4	0.60	35,826
Fattening swine:					
First period,	36.0	5.0		27.5	60,450
Second period,	31.0	4.0		24.0	52,080
Third period,	23.5	2.7		17.5	37,570

B.—Per Day and Per Head.

	Average live weight per head.	Total organic matter.	Digestible Food Materials.			Fuel value.
			Protein.	Carbohydrates.	Fat.	
	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.	Calories.
Growing cattle:						
Age—						
2 to 3 months,	150	3.3	0.6	2.1	0.30	5,116
3 to 6 months,	300	7.0	1.0	4.1	0.30	10,750
6 to 12 months,	500	12.0	1.3	6.8	0.30	16,332
12 to 18 months,	700	16.8	1.4	9.1	0.28	20,712
18 to 24 months,	850	20.4	1.4	10.3	0.26	22,859
Growing sheep:						
Age—						
5 to 6 months,	56	1.6	0.18	0.87	0.045	2,149
6 to 8 months,	67	1.7	0.17	0.85	0.040	2,066
8 to 11 months,	75	1.7	0.16	0.85	0.037	2,035
11 to 15 months,	82	1.8	0.14	0.89	0.032	2,051
15 to 20 months,	85	1.9	0.12	0.88	0.025	1,966
Growing fat swine:						
Age—						
2 to 3 months,	50	2.1	0.38		1.50	3,496
3 to 5 months,	100	3.4	0.50		2.50	5,580
5 to 6 months,	125	3.9	0.54		2.96	6,510
6 to 8 months,	170	4.6	0.58		3.47	7,533
8 to 12 months,	250	5.2	0.62		4.05	8,686

FERTILIZING CONSTITUENTS OF AMERICAN FEEDING STUFFS AND MANURIAL VALUE PER TON.

Taken from Bulletin No. 16, Prepared by Enos H. Hess, of the State Experiment Station, Pennsylvania.

In commercial fertilizers there are only three ingredients which are assumed to have any practical value, namely: Nitrogen, phosphoric acid and potash. The foods used in feeding dairy cattle contain more or less of these three ingredients, and, therefore, have a fertilizing value equal to the amount of nitrogen, phosphoric acid and potash they contain. The nitrogen is valued at twelve cents per pound, the phosphoric acid at four cents and potash at five cents per pound. No allowance is made for the value of the humus, which has some value, but as to how much it has, will have to be left to the judgment of the reader, for as yet it has not been scientifically determined.

	Pounds in 100 Pounds.			Manurial Value in Dollars per Ton.			
	Nitrogen.	Phosphoric acid.	Potash.	Nitrogen.	Phosphoric acid.	Potash.	Total.
SOILING FODDER.	Lbs.	Lbs.	Lbs.				
Corn—dent, cut before glazing,	0.41	0.14	0.33	$0.984	$0.120	$0.33	$1.43
Cow pea,	0.27	0.10	0.31	.648	.080	.31	1.01
Crimson clover (just heading),*	0.40	0.12	0.34	.960	0.96	.34	1.40
Crimson clover (full bloom),*	0.51	0.12	0.35	1.224	.096	.35	1.67
Orchard grass (in bloom),	0.43	0.16	0.76	1.032	.128	.76	1.92
Pasture grass,*	0.75	0.19	0.60	1.800	.152	.60	2.55
Red clover,	0.53	0.13	0.46	1.272	.104	.46	1.84
Rye,	0.33	0.15	0.73	.792	.120	.73	1.64
Soja bean,	0.29	0.15	0.53	.696	.120	.53	1.35
SILAGE.							
Corn silage—average of all analyses,	0.28	.011	0.37	.672	.088	.37	1.13
Red clover,	0.53	0.13	0.46	1.272	.104	.46	1.84
HAY, STRAW, ETC.							
Alfalfa hay,	2.19	0.51	1.68	5.256	.458	1.68	7.34
Corn fodder—field cured,	1.76	0.54	0.89	4.225	.432	.89	5.55
Corn stover—field cured,	1.04	0.29	1.40	2.496	.232	1.40	4.13
Clover hay—red,	2.07	0.38	2.20	4.968	.304	2.20	7.47
Hungarian grass hay,	1.20	0.35	1.30	2.880	.280	1.30	4.46
Mixed meadow grass hay,*	1.02	0.26	1.48	2.448	.208	1.48	4.14
Mixed hay,	1.67	0.46	1.55	4.009	.368	1.55	5.93
Oat straw,	0.62	1.24	1.24	1.488	.160	1.24	2.89
Orchard grass hay,	1.31	0.01	1.88	3.144	.328	1.88	5.35
Red top hay,	1.15	0.36	1.02	2.760	.288	7.02	4.07
Rye straw,	0.46	0.28	0.79	1.104	.224	.79	2 .12
Timothy hay,	1.26	0.53	0.90	3.024	.424	.90	4.35
Wheat straw,	0.59	0.70	0.42	1.896	.560	.42	2.88
Wheat chaff,	0.79	0.70	0.42	1.896	.560	.42	2.88

*Taken from New Jersey report for 1894.

Fertilizing Constituents of American Feeding Stuffs and Manurial Value Per Ton—Continued.

	Pounds in 100 Pounds.			Manurial Value in Dollars per Ton.			
	Nitrogen.	Phosphoric acid.	Potash.	Nitrogen.	Phosphoric acid.	Potash.	Total.
	Lbs.	Lbs.	Lbs.				
ROOTS AND TUBERS.							
Carrots,	0.15	0.09	0.51	.361	.072	.51	.94
Mangel wurzels,	0.19	0.09	0.38	.456	.072	.38	.91
Potatoes,	0.21	0.07	0.29	.504	.056	.29	.85
Rutabagas,	0.19	0.12	0.49	.456	.096	.49	1.04
Sugar beets,	0.22	0.10	0.48	.528	.080	.39	.90
Turnips,	0.18	0.10	0.39	.432	.080	.39	.90
GRAIN.							
Barley,	1.51	0.79	0.48	3.625	.632	.48	4.74
Buckwheat,	1.44	0.44	0.21	3.456	.352	.21	4.02
Corn—dent,*	1.65	0.70	0.40	3.961	.560	.40	4.92
Corn—flint,*	1.68	0.70	0.40	4.033	.560	.40	4.99
Corn—sweet,*	1.82	0.72	0.41	4.369	.576	.41	5.36
Oats,	2.06	0.82	0.62	4.945	.656	.62	6.22
Peas,	3.08	0.82	0.99	7.393	.656	.99	9.04
Rye,	1.76	0.82	0.54	4.225	.656	.54	5.42
Sorghum seed,	1.48	0.81	0.42	3.553	.648	.42	4.62
Wheat—spring,	2.36	0.70	0.39	5.665	.500	.39	6.62
Wheat—winter,	2.36	0.89	0.61	5.665	.712	.61	6.99
MILL PRODUCTS.							
Barley meal,	1.55	0.66	0.34	3,720	.528	.34	4.59
Buckwheat middlings,	4.62	1.73	1.56	11.088	1.384	1.560	14.032
Corn meal,	1.58	0.63	0.40	3.792	.504	.40	4.70
Corn-and-cob meal,	1.41	0.57	0.47	3.384	.456	.47	4.31
Pea meal,	3.08	0.82	0.99	7.392	.656	.99	9.04
Rye bran,	2.32	2.28	1.40	5.568	1.824	1.40	8.79
Wheat bran,	2.67	2.89	1.61	6.408	2.312	1.61	10.33
Wheat middlings,	2.63	0.95	0.63	6.312	.760	.63	7.70
Wheat shorts,*	2.42	1.38	0.65	5.808	1.404	.65	7.56
BY-PRODUCTS AND WASTE MATERIAL.							
Apple pomace,	0.23	0.02	0.13	0.552	0.016	.013	0.70
Brewers' grains—dried,	3.05	1.26	1.55	7.320	1.008	1.55	9.88
Brewers' grains—wet,	0.89	0.31	0.05	2.136	.248	.05	2.43
Cerealine feed,*	1.69	1.25	0.67	4.056	1.000	.67	5.73
Corn oil meal,*	3.96	1.45	0.17	9.504	1.160	.17	10.83
Corn cobs,	0.50	0.06	0.60	1.200	.048	.60	1.85
Cottonseed hulls,	0.75	0.18	1.08	1.800	.144	1.08	3.02
Cottonseed meal,	6.64	2.68	1.79	15.936	2.144	1.79	19.87
Gluten meal,	5.03	9.33	0.05	12.072	.264	.05	12.39
Buffalo gluten feed,*	3.44	0.38	0.07	8.256	.304	.07	8.63
Chicago gluten meal,*	5.52	0.29	0.05	13.284	.232	.05	13.53
Grano gluten feed,*	4.96	0.66	0.20	11.904	.528	.20	12.63
Germ meal,*	3.48	6.16	2.91	8.352	4.928	2.91	16.19
Linseed meal—new process,	5.78	1.83	1.39	13.872	1.464	1.39	16.73
Linseed meal—old process,	5.43	1.66	1.37	13.032	1.328	1.37	15.73
Malt sprouts,	3.55	1.43	1.63	8.250	1.144	1.63	11.29
DAIRY PRODUCTS.							
Butter,	0.12	0.04	0.04	.238	.032	.04	.36
Butter milk,	0.48	0.17	0.16	1.152	.136	.16	1.45
Cheese,	3.93	0.60	0.12	9.432	.480	.12	10.03
Cream,	0.40	0.15	0.13	.960	.120	.13	1.21
Milk,	0.53	0.19	0.18	1.272	.152	.18	1.00
Skim milk,	0.56	0.20	0.19	1.344	.160	.19	1.69
Whey,	0.15	0.14	0.18	.360	.112	.18	.65

*Taken from New Jersey report for 1894.

The above table shows a very wide range in the fertilizing value of the different dairy foods and products. The highest value per ton is $19.87 for cottonseed meal and the lowest is 36 cents for butter. The importance of the fertilizing value of foods is, therefore, clearly seen and must be carefully studied, if the maximum results are to be obtained.

FIFTY DAIRY RULES.

From the Report of the Bureau of Animal Industry of the United States in 1898.

The Owner and His Helpers.

1. Read current dairy literature and keep posted on new ideas.

2. Observe and enforce the utmost cleanliness about the cattle, their attendants, the stable, the dairy, and all utensils.

3. A person suffering from any disease, or who has been exposed to a contagious disease, must remain away from the cows and the milk.

The Stable.

4. Keep dairy cattle in a room or building by themselves. It is preferable to have no cellar below and no storage loft above.

5. Stables should be well ventilated, lighted and drained; should have tight floors and walls and be plainly constructed.

6. Never use musty or dirty litter.

7. Allow no strongly smelling material in the stable for any length of time. Store the manure under cover outside the cow stable and remove it to a distance as often as practicable.

8. Whitewash the stable once or twice a year. Use land plaster in the manure gutters daily.

9. Use no dry, dusty feed just previous to milking; if fodder is dusty, sprinkle it before it is fed.

10. Clean and thoroughly air the stable before milking. In hot weather sprinkle the floor.

11. Keep the stable and dairy room in good condition, and then insist that the dairy, factory, or place where the milk goes be kept equally well.

The Cows.

12. Have the herd examined at least twice a year by a skilled veterinarian.

13. Promptly remove from the herd any animal suspected of being in bad health and reject her milk. Never add an animal to the herd until certain it is free from disease, especially tuberculosis.

14. Do not move cows faster than a comfortable walk while on the way to place of milking or feeding.

15. Never allow the cows to be excited by hard driving, abuse,

loud talking or unnecessary disturbance; do not expose them to cold or storm.

16. Do not change the feed suddenly.

17. Feed liberally, and use only fresh, palatable feed stuffs; in no case should decomposed or moldy material be used.

18. Provide water in abundance, easy of access, and always pure; fresh, but not too cold.

19. Salt should always be accessible.

20. Do not allow any strong-flavored food, like garlic, cabbage, and turnips, to be eaten, except immediately after milking.

21. Clean the entire body of the cow daily. If hair in the region of the udder is not easily kept clean it should be clipped.

22. Do not use the milk within twenty days before calving nor within three to five days afterwards.

Milking.

23. The milker should be clean in all respects; he should not use tobacco; he should wash and dry his hands just before milking.

24. The milker should wear a clean outer garment; used only when milking, and kept in a clean place at other times.

25. Brush the udder and surrounding parts just before milking, and wipe them with a clean, damp cloth or sponge.

26. Milk quietly, quickly, cleanly and thoroughly. Cows do not like unnecessary noise or delay. Commence milking at exactly the same hour every morning and evening, and milk the cows in the same order.

27. Throw away (but not on the floor, better in the gutter) the first few streams from each teat; this milk is very watery and of little value, but it may injure the rest.

28. If in any milking a part of the milk is bloody or stringy or unnatural in appearance, the whole mess should be rejected.

29. Milk with dry hands; never allow the hands to come in contact with the milk.

30. Do not allow dogs, cats or loafers to be around at milking time.

31. If any accident occurs by which a pail full or partly full of milk becomes dirty, do not try to remedy this by straining, but reject all this milk and rinse the pail.

32. Weigh and record the milk given by each cow, and take a sample morning and night, at least once a week, for testing by the fat test.

Care of Milk.

33. Remove the milk of every cow at once from the stable to a clean, dry room, where the air is pure and sweet. Do not allow cans to remain in stables while they are being filled.

34. Strain the milk through a metal gauze and a flannel cloth or layer of cotton as soon as it is drawn.

35. Aerate and cool the milk as soon as strained. If an apparatus for airing and cooling at the same time is not at hand, the milk should be aired first. This must be done in pure air, and it should then be cooled to 45 degrees if the milk is for shipment, or to 60 degrees if for home use or delivery to a factory.

36. Never close a can containing warm milk which has not been aerated.

37. If cover is left off can, a piece of cloth or mosquito netting should be used to keep out insects.

38. If milk is stored, it should be held in tanks of fresh, cold water (renewed daily), in a clean, dry clad room. Unless it is desired to remove cream, it should be stirred with a tin stirrer often enough to prevent forming a thick cream layer.

39. Keep the night milk under shelter so rain can not get into the cans. In warm weather hold in a tank of fresh cold water.

40. Never mix fresh warm milk with that which has been cooled.

41. Do not allow milk to freeze.

42. Under no circumstances should anything be added to milk to prevent its souring. Cleanliness and cold are the only preventatives needed.

43. All milk should be in good condition when delivered. This may make it necessary to deliver twice a day during the hottest weather.

44. When cans are hauled far they should be full, and carried in a spring wagon.

45. In hot weather cover the cans, when moved in a wagon, with a clean, wet blanket or canvas.

The Utensils.

46. Milk utensils for farm use should be made of metal and have all joints smoothly soldered. Never allow them to become rusty or rough inside.

47. Do not haul waste products back to the farm in the same cans used for delivering milk. When this is unavoidable, insist that the skim milk or whey tank be kept clean.

48. Cans used for the return of skim milk or whey should be emptied and cleaned as soon as they arrive at the farm.

49. Clean all dairy utensils by first thoroughly rinsing them in warm water; then clean inside and out with a brush and hot water in which a cleaning material is dissolved; then rinse and, lastly, sterilize by boiling water or steam. Use pure water only.

50. After cleaning, keep utensils inverted, in pure air and sun, if possible, until wanted for use.

PERIOD OF GESTATION IN DOMESTIC ANIMALS.

FROM ANIMAL INDUSTRY, (*Shaw.*)

The average duration, approximately, of the period of gestation in domestic quadrupeds may be given as follows:

The ass,	365 days.	The sow,	113 days.
The mare,	330 days.	The dog,	63 days.
The cow,	282 days.	The cat,	50 days.
The sheep,	149 days.	The rabbit,	30 days.
The goat,	149 days.	The guinea-pig,	21 days.

The average duration, approximately, of the period in hatching the eggs of the various domestic breeds of fowls may be set down as follows:

The goose,	30 days.	The guinea-hen,	26 days.
The turkey,	29 days.	The hen,	21 days.
The duck,	29 days.	The pigeon,	18 days.
The pea-hen,	28 days.		

The extremes in the duration of the period of gestation in the mare, the cow, the ewe and the sow may be set down as follows:

The mare,	295 days to 370 days.
The cow,	265 days to 300 days.
The ewe,	145 days to 154 days.
The sow,	110 days to 118 days.

The extremes in the duration of the period of incubation in the various classes of domestic fowls named below may be given as follows:

The goose,	27 days to 33 days.
The turkey,	26 days to 30 days.
The duck,	26 days to 32 days.
The pea-hen,	28 days to 30 days.
The guinea-hen,	25 days to 26 days.
The pigeon,	16 days to 20 days.

THE FUNCTIONS AND USES OF FOODS.*

BY C. F. LANGWORTHY, PH. D., *Office of Experiment Stations.*

Circular No. 46, United States Department of Agriculture.

Ordinary food materials, such as meat, fish, eggs, potatoes, wheat, etc., consist of—

Refuse.—As the bones of meat and fish, shells of shellfish, skins of potatoes, bran of wheat, etc.

Edible Portion.—As the flesh of meat and fish, the white and yolk of eggs, wheat flour, etc. The edible portion consists of water and nutritive ingredients, or nutrients. The nutritive ingredients are protein, fats, carbohydrates and mineral matters.

The water, refuse and salt of salted meat and fish are called non-nutrients. In comparing the values of different food materials for nourishment they are left out of account.

Use of Nutrients.

Food is used in the body to build and repair tissue and to furnish energy. The manner in which the valuable constituents are utilized in the body may be expressed in tabular form as follows:

Protein, White (albumen) of eggs, curd (casein) of milk, lean meat, gluten of wheat, etc.	Forms tissue (muscles, tendon, and probably fat).	All serve as fuel and yield energy in form of heat and muscular strength.
Fats, Fat of meat, butter, olive oil, oils of corn and wheat, etc.	Form fatty tissue.	
Carbohydrates, Sugar, starch, etc.	Transformed into fat.	
Mineral matters (ash), Phosphates of lime, potash, soda, etc.	Aid in forming bone, assist in digestion, etc.	

*This article, which was originally published under the title "Foods for Man," in the U. S. Dept. Agr. Yearbook, 1897, pp. 676-682, has been revised and contains some additional matter.

The Fuel Value of Food.—Heat and muscular power are forms of force or energy. The energy is developed as the food is consumed in the body. The unit commonly used in this measurement is the calorie, the amount of heat which would raise the temperature of a pound of water 4 degrees F.

Instead of this unit, some unit of mechanical energy might be used—for instance, the foot-ton, which represents the force re-

quired to raise one ton one foot. One calorie is equal very nearly to 1.53 foot-tons.

The following general estimate has been made for the average amount of potential energy in one pound of each of the classes of nutrients:

	Calories.
In one pound of protein,	1,860
In one pound of fats,	4,220
In one pounds of carbohydrates,	1,860

In other words, when we compare the nutrients in respect to their fuel values, their capacities for yielding heat and mechanical power, a pound of protein of lean meat or albumen of egg is just about equivalent to a pound of sugar or starch, and a little over two pounds of either would be required to equal a pound of the fat of meat or butter or the body fat.

Within recent years analyses of a large number of samples of foods have been made in this country. In the table below the average results of a number of these analyses are given:

Average Composition of American Food Products. (*)

Food Materials (as purchased).	Refuse. Per cent.	Water. Per cent.	Protein. Per cent.	Fat. Per cent.	Carbohydrates. Per cent.	Ash. Per cent.	Fuel value per pound. Calories.
ANIMAL FOOD.							
Beef, fresh:							
Chuck, including shoulder,	17.3	54.0	15.8	12.5	....	0.7	820
Chuck ribs,	19.1	53.8	15.3	11.1	....	.8	755
Flank,	5.5	56.1	18.6	19.9	....	.8	1,185
Loin,	13.3	52.9	16.4	16.9	....	.9	1,020
Porterhouse steak,	12.7	52.4	19.1	17.9	....	.8	1,110
Sirloin steak,	12.8	54.0	16.5	16.1	....	.9	985
Neck,	31.8	45.3	14.2	9.2	....	.7	650
Ribs,	20.1	45.3	14.4	30.0	....	.7	1,110
Rib rolls,	....	64.8	19.4	15.5	....	.9	1,105
Round,	8.5	62.5	19.2	9.2	....	1.0	745
Rump,	19.5	46.9	15.2	18.6	....	.8	1,065
Shank, fore,	38.3	43.2	13.2	5.2	....	.6	465
Shoulder and clod,	17.4	57.0	16.5	8.4	....	.9	660
Fore quarter,	20.6	49.5	14.4	15.1	....	.7	905
Hind quarter,	16.3	52.0	16.1	15.4	....	.8	950
Beef, corned, canned, pickled and dried:							
Corned beef,	8.4	49.2	14.3	23.8	....	4.6	1,271
Tongue, pickled,	6.0	68.9	11.9	19.2	....	4.3	1,030
Dried, salted and smoked,	4.7	53.7	26.4	6.9	....	8.9	780
Canned boiled beef,	....	51.8	25.5	22.5	....	1.3	1,425
Canned corned beef,	....	51.8	26.3	18.7	....	4.0	1,280
Veal:							
Breast,	23.3	52.5	15.7	8.2	....	.8	635
Leg,	11.7	63.4	18.3	5.8	....	1.0	585
Leg cutlets,	3.4	68.3	20.1	7.5	....	1.0	690
Fore quarter,	24.5	54.2	15.1	6.0	....	.7	535
Hind quarter,	20.7	56.2	16.2	6.6	....	.8	580
Mutton:							
Flank,	9.9	39.0	13.8	36.9	....	.6	1,815
Leg, hind,	17.7	51.9	15.4	14.5	....	.8	900
Shoulder,	22.1	46.8	13.7	17.1	....	.7	975
Fore quarter,	21.2	41.6	12.3	24.5	....	.7	1,265
Hind quarter, without tallow,	19.3	43.3	13.0	24.0	....	.7	1,255
Lamb:							
Breast,	19.8	45.5	15.4	19.1	....	.8	1,090
Leg, hind,	13.8	50.3	16.0	19.7	....	.9	1,130
Pork, fresh:							
Flank,	18.0	48.5	15.1	18.6	....	.7	1,065
Ham,	10.3	45.1	14.3	29.7	....	.8	1,520
Loin chops,	19.3	40.8	13.2	26.0	....	.8	1,340
Shoulder,	12.4	44.9	12.0	29.8	....	.7	1,480
Tenderloin,	....	66.5	18.9	13.0	....	1.0	900
Pork, salted, cured and pickled:							
Ham, smoked,	12.2	35.8	14.5	33.2	....	4.2	1,670
Shoulder, smoked,	18.9	30.7	12.6	33.0	....	5.0	1,625
Salt pork,	....	7.9	1.9	86.2	....	3.9	3,670
Bacon, smoked,	8.7	18.4	9.5	59.4	....	4.5	2,685
Sausage:							
Bologna,	3.3	55.2	18.2	19.7	....	3.8	1,170
Farmer,	3.9	22.2	27.9	40.4	....	7.3	2,225
Frankfort,	....	57.2	19.6	18.6	1.1	3.4	1,170
Soups:							
Celery, cream of,	....	88.6	2.1	2.8	5.0	1.5	250
Beef,	....	92.9	4.4	.4	1.1	1.2	120
Meat stew,	....	84.5	4.6	4.3	5.5	1.1	370
Tomato,	....	90.0	1.8	1.1	4.6	1.5	185
Poultry:							
Chicken, broilers,	41.6	43.7	12.8	1.4	....	.7	295
Fowls,	25.9	47.1	13.7	12.3	....	.7	775
Goose,	17.6	38.5	13.4	29.8	....	.7	1,505
Turkey,	22.7	42.4	16.1	18.4	....	.8	1,075
Fish:							
Cod, dressed,	20.9	58.5	11.1	.2	....	.8	215
Halibut, steaks or sections,	17.7	67.9	15.3	4.4	....	.9	470
Mackerel, whole,	44.7	40.0	10.2	4.2	....	.7	365
Perch, yellow, dressed,	35.1	50.7	12.8	.7	....	.9	265
Shad, whole,	50.1	35.2	9.4	4.8	....	.7	380
Shad, roe,	....	71.2	20.9	3.8	2.6	1.5	600
Fish, salt, cod,	24.9	40.2	10.0	.4	....	18.5	315

*Condensed from detailed tables in Bulletin No. 28, revised, of the Office of Experiment Stations of this Department.

Average Composition of American Food Products—Continued.

Food Materials (as purchased).	Refuse. Per cent.	Water. Per cent.	Protein. Per cent.	Fat. Per cent.	Carbohydrates. Per cent.	Ash. Per cent.	Fuel value per pound. Calories.
ANIMAL FOOD—Continued.							
Fish, canned:							
Salmon,	14.2	56.8	19.5	7.5	....	2.0	680
Sardines,	*5.0	53.6	23.7	12.1	....	5.3	950
Shellfish:							
Oyster, "solids,"	....	88.3	6.0	1.3	3.3	1.1	230
Clams,	....	80.8	10.6	1.1	5.2	2.3	340
Crabs,	52.4	36.7	7.9	.9	.6	1.5	195
Lobsters,	61.7	30.7	5.9	.7	.2	.8	140
Eggs: Hens' eggs,	†11.2	65.5	11.9	9.3	....	.9	635
Dairy products, etc.:							
Butter,	....	11.0	1.0	85.0	....	3.0	3,605
Whole milk,	....	87.0	3.3	4.0	5.0	.7	325
Skim milk,	....	90.5	3.4	.3	5.1	.7	170
Buttermilk,	....	91.0	3.0	.5	4.8	.7	165
Condensed milk,	....	26.9	8.8	8.3	54.1	1.9	1,520
Cream,	....	74.0	2.5	18.5	4.5	.5	910
Cheese, Cheddar,	....	27.4	27.7	36.8	4.1	4.0	2,145
Cheese, full cream,	....	34.2	25.9	33.7	2.4	3.8	1,950
VEGETABLE FOOD.							
Flour, meal, etc.:							
Entire wheat flour,	....	11.4	13.8	1.9	71.9	1.0	1,675
Graham flour,	....	11.3	13.3	2.2	71.4	1.8	1,670
Wheat flour, patent roller process:							
High grade and medium,	....	12.0	11.4	1.0	75.1	.5	1,650
Low grade,	....	12.0	14.0	1.9	71.2	.9	1,665
Macaroni,	....	78.4	3.0	1.5	15.8	1.3	415
Crushed wheat,	....	10.1	11.1	1.7	75.5	1.6	1,605
Buckwheat flour,	....	13.6	6.4	1.2	77.9	.9	1,620
Corn meal,	....	12.5	9.2	1.9	75.4	1.0	1,655
Oatmeal,	....	7.3	16.1	7.2	67.5	1.9	1,860
Rice,	....	12.3	8.0	.3	79.0	.4	1,640
Tapioca,	....	11.4	.4	.1	88.0	.1	1,650
Starch,	....	....	....	....	90.0	....	1,675
Bread, pastry, etc.:							
White bread,	....	35.3	9.2	1.3	53.1	1.1	1,215
Brown bread,	....	43.6	5.4	1.8	47.1	2.1	1,050
Graham bread,	....	35.7	8.9	1.8	52.1	1.5	1,210
Whole wheat bread,	....	38.4	9.7	.9	49.7	1.3	1,140
Rye bread,	....	35.7	9.0	.6	53.2	1.5	1,180
Cake,	....	19.9	6.3	9.0	63.3	1.5	1,675
Cream crackers,	....	6.8	9.7	12.1	69.7	1.7	1,990
Oyster crackers,	....	4.8	11.3	10.5	70.5	2.9	1,965
Soda crackers,	....	5.9	9.8	9.1	73.1	2.1	1,925
Sugars, etc.:							
Molasses,	....	25.1	2.4	....	69.3	3.2	1,290
Candy,	....	....	....	....	96.0	....	1,785
Honey,‡	....	18.2	.4	....	81.2	.2	1,520
Sugar, granulated,	....	....	....	....	100.0	....	1,860
Maple syrup,	....	....	....	....	71.4	....	1,300
Vegetables:§							
Beans, dried,	....	12.6	22.5	1.8	59.6	3.5	1,695
Beans, Lima, shelled,	....	68.5	7.1	.7	22.0	1.7	570
Beans, string,	7.0	83.0	2.1	.3	6.9	.7	180
Beets,	20.0	70.0	1.3	.1	7.7	.9	170
Cabbage,	15.0	77.7	1.4	.2	4.8	.9	125
Celery,	20.0	75.6	.9	.1	2.6	.8	70
Corn, green (sweet), edible portion,	....	75.4	3.1	1.1	19.7	.7	470
Cucumbers,	15.0	81.1	.7	.2	2.6	.4	70
Lettuce,	15.0	80.5	1.0	.2	2.5	.8	75
Mushrooms,	....	88.1	3.5	.4	6.8	1.2	210
Onions,	10.0	78.9	1.4	.3	8.9	.5	205
Parsnips,	20.0	66.4	1.3	.4	10.8	1.1	240
Peas (Pisum sativum), dried,	....	9.5	24.6	1.0	62.0	2.9	1,655

*Refuse, oil.

†Refuse, shell.

‡Contained on an average, cane sugar 2.8 and reducing sugar 71.1 per cent. The reducing sugar was composed of about equal amounts of glucose (dextrose) and fruit sugar (levulose).

§Such vegetables as potatoes, squash, beets, etc., have a certain amount of inedible material, skin, seeds, etc. The amount varies with the method of preparing the vegetables, and can not be accurately estimated. The figures given for refuse of vegetables, fruits, etc., are assumed to represent approximately the amount of refuse in these foods as ordinarily prepared.

Average Composition of American Food Products—Continued.

Food Materials (as purchased).	Refuse. Per cent.	Water. Per cent.	Protein. Per cent.	Fat. Per cent.	Carbohydrates. Per cent.	Ash. Per cent.	Fuel value per pound. Calories.
VEGETABLE FOOD—Continued.							
Vegetables:*—Continued.							
Peas (Pisum sativum), shelled,	....	74.6	7.0	0.5	16.9	1.0	465
Cow peas, dried,	....	13.0	21.4	1.4	60.8	3.4	1,590
Potatoes,	20.0	62.6	1.8	.1	14.7	.8	310
Rhubarb,	40.0	56.6	.4	.4	2.2	.4	65
Sweet potatoes,	20.0	55.2	1.4	.6	21.9	.9	640
Spinach,	....	92.3	2.1	.3	3.2	2.1	110
Squash,	50.0	44.2	.7	.2	4.5	.4	105
Tomatoes,	....	94.3	.9	.4	3.9	.5	105
Turnips,	30.0	76.7	.9	.1	5.7	.6	125
Vegetables, canned:							
Peas (Pisum sativum), green,	....	85.3	3.6	.2	9.8	1.1	255
Corn, green,	....	76.1	2.8	1.2	19.0	.9	455
Tomatoes,	....	94.0	1.2	.2	4.0	.6	105
Fruits, berries, etc., fresh: †							
Apples,	25.0	63.4	.3	.3	10.8	.3	220
Bananas,	35.0	48.9	.8	.4	14.3	.6	300
Grapes,	25.0	58.0	1.0	1.2	14.4	.4	305
Lemons,	30.0	62.5	.7	.5	5.9	.4	145
Muskmelons,	50.0	44.8	.3	....	4.6	.3	90
Oranges,	27.0	63.4	.6	.1	8.5	.4	170
Pears,	10.0	76.0	.5	.4	12.7	.4	260
Persimmons, edible portion,	....	66.1	.8	.7	31.5	.9	630
Raspberries,	....	85.8	1.0	....	12.6	.6	255
Strawberries,	5.0	85.9	.9	.6	7.0	.6	175
Watermelons,	59.4	37.5	.2	.1	2.7	.1	60
Fruits, dried:							
Apples,	....	28.1	1.6	2.2	66.1	2.0	1,350
Apricots,	....	81.4	.9	....	17.3	.4	340
Dates,	10.0	13.8	1.9	2.5	70.6	1.2	1.450
Figs,	....	18.8	4.3	.3	74.2	2.4	1.475
Nuts:							
Almonds,	45.0	2.7	11.5	30.2	9.5	1.1	1,660
Beechnuts,	40.8	2.3	13.0	34.0	7.8	2.1	1,820
Brazil nuts,	49.6	2.6	8.6	33.7	3.5	2.0	1,655
Butternuts,	86.4	.6	3.8	8.3	.5	.4	430
Chestnuts, fresh,	16.0	37.8	5.2	4.5	35.4	1.1	945
Chestnuts, dried,	24.0	4.5	8.1	5.3	56.4	1.7	1,425
Cocoanuts,	‡48.8	7.2	2.9	25.9	14.3	.9	1,415
Cocoanut, prepared,	....	3.5	6.3	57.4	31.5	1.3	3,125
Filberts,	52.1	1.8	7.5	31.3	6.2	1.1	1,575
Hickory nuts,	62.2	1.4	5.8	25.5	4.3	.8	1,265
Pecans, polished,	53.2	1.4	5.2	33.3	6.2	.7	1,620
Peanuts,	24.5	6.9	19.5	29.1	18.5	1.5	1,935
Pinon (Pinus edulis),	40.6	2.0	8.7	36.8	10.2	1.7	1,905
Walnuts, California, black,	74.1	.6	7.2	14.6	3.0	.5	805
Walnuts, California, soft shell,	58.1	1.0	6.9	26.6	6.8	.6	1,375
Raisins,	10.0	13.1	2.3	3.0	68.5	3.1	1,445
Miscellaneous:							
Chocolate,	....	5.9	12.9	48.7	30.3	2.2	2,860
Cocoa, powdered,	....	4.6	21.6	28.9	37.7	7.2	2,320
Cereal coffee, infusion (1 part boiled in 20 parts water),§	....	98.2	.2	....	1.4	[illegible]	[illegible]

*Such vegetables as potatoes, squash, beets, etc., have a certain amount of inedible material, skin, seeds, etc. The amount varies with the method of preparing the vegetables, and can not be accurately estimated. The figures given for refuse of vegetables, fruits, etc., are assumed to represent approximately the amount of refuse in these foods as ordinarily prepared.

†Fruits contain a certain proportion of inedible materials, as skin, seeds, etc., which are properly classed as refuse. In some fruits, as oranges and prunes, the amount rejected in eating is practically the same as refuse. In others, as apples and pears, more or less of the edible material is ordinarily rejected with the skin and seeds and other inedible portions. The edible material which is thus thrown away, and should properly be classed with the waste, is here classed with the refuse. The figures for refuse here given represent, as nearly as can be ascertained, the quantities ordinarily rejected.

‡Milk and shell.

§The average of five analyses of cereal coffee grain is: Water 6.2, protein 13.3, fat 3.4, carbohydrates 72.6, and ash 4.5 per cent. Only a portion of the nutrients, however, enter into the infusion. The average in the table represents the available nutrients in the beverage. Infusions of genuine coffe and of tea like the above contain practically no nutrients.

Dietary Standards.

Dietary studies have been made in considerable numbers in different countries. The results of such studies and experiments to determine the amount of food required by men engaged in different occupations have resulted in the adoption of dietary standards. Some of these follow:

Standards for Daily Dietaries.

Character of Work to be Performed.	Nutrients.			Fuel value. Calories.
	Protein. Pound.	Fat. Pound.	Carbohydrates. Pounds.	
European:				
Man at moderate work,	0.26	0.12	1.10	3,055
Man at hard work,	.32	.22	.99	3,370
American:				
Man without muscular work,	.20	....	....	3,000
Man with light muscular work,	.22	....	....	3,000
Man with moderate muscular work,	.28	....	....	3,500
Man with hard muscular work,	.39	....	....	4,500

The table of composition of food materials shows the amount of water, protein, fat, carbohydrates, and ash content and the total fuel value per pound for each kind of food named. The protein, fat and carbohydrates all furnish energy. In addition to furnishing energy, protein forms tissue. Since protein and energy are the essential features of food, dietary standards may be expressed in their simplest form in terms of protein and energy alone.

Observation has shown that as a rule a woman requires less food than a man, and the amount required by children is still less, varying with the age. It is customary to assign certain factors which shall represent the amount of nutrients required by children of different ages and by women as compared with adult man. The various factors which have been adopted are as follows:

Factors used in Calculating Meals Consumed in Dietary Studies.

One meal of woman equivalent to 0.8 meal of man at moderate muscular labor.

One meal of boy 14 to 16 years of age, inclusive, equivalent to 0.8 meal of man.

One meal of girl 14 to 16 years of age, inclusive, equivalent to 0.7 meal of man.

One meal of child 10 to 13 years of age, inclusive, equivalent to 0.6 meal of man.

One meal of child 6 to 9 years of age, inclusive, equivalent to 0.5 meal of man.

One meal of child 2 to 5 years of age, inclusive, equivalent to 0.4 meal of man.

One meal of child under 2 years of age equivalent to 0.3 meal of man.

These factors are based in part upon experimental data and in part upon arbitrary assumptions. They are subject to revision when experimental evidence shall warrant more definite conclusions.

The plan followed in making dietary studies is, briefly, as follows: Exact account is taken of all the food materials (1) at the beginning of the study, (2) purchased during the study, and (3) remaining at the end. The difference between the third and the sum of the first and second is taken as representing the amount used. From the figures thus obtained the amount of the different food materials and the amount of the different nutrients furnished by them is calculated. Deducting from this the weights of the nutrients found in the kitchen and table refuse, the amounts actually consumed are obtained. Account is also taken of the meals eaten by different members of the family or groups studied and by visitors, if there are any. From the total food eaten by all the persons during the entire period the amount eaten per man per day may be calculated. In making these calculations due account is taken of the fact that, as stated above, women and children eat less than men performing the same amount of work.

Method of Calculating Dietaries.

The following may be taken as an illustration of the way in which the table of composition of food products and the dietary standards may be practically applied. Suppose the family consists of four adults, and that there are on hand, or may be readily purchased, the following food materials: Oatmeal, milk, sugar, eggs, lamb chops, roast beef, potatoes, sweet potatoes, rice, bread, cake, bananas, tea, and coffee. From these materials menus for three meals might be arranged as follows:

Breakfast.—Oatmeal, milk, sugar, lamb chops, bread, butter and coffee.

Dinner.—Roast beef, potatoes (Irish), sweet potatoes, rice pudding, and tea.

Supper.—Bread, butter, cake, and bananas.

The amounts required of the several articles of food may be readily approximated by any person experienced in marketing or preparing food for a family. Thus, it may be assumed that four adults would consume for breakfast 1½ pounds lamb chops, one-half pound oatmeal, one-half pound bread, 6 ounces milk, 2 ounces sugar,

and 2 ounces butter. From the table of composition of food materials the nutritive ingredients which these foods furnish may be easily calculated. Thus, if oatmeal contains 16.1 per cent. of protein and furnishes 1,860 calories per pound, one-half pound would contain 0.081 pound protein ($0.5 \times 0.161 = 0.081$ pound) and yield 930 calories ($0.5 \times 1.860 = 930$), and if lamb chops contain 16 per cent. protein and furnish 1,130 calories per pound, $1\frac{1}{2}$ pounds of lamb chops would furnish 0.24 pounds protein (1.5 pounds $\times$ 0.16 = 0.24 pound) and 1,695 calories (1.5 pounds $\times$ 1,130 = 1,695) calories. The others may be calculated in the same way.

The assumed quantities of food materials which the four persons would consume in a day, and the calculated protein content and fuel value, would be as follows:

Menu for Family of Four Adults for One Day.

Food Materials.	Weights. Pounds.	Weights. Ounces.	Protein. Pound.	Fuel value. Calories.
Breakfast.				
Oatmeal,	....	8	0.081	930
Milk,	....	6	.012	122
Sugar,	....	2	....	232
Lamb chops (from leg),	1	8	.240	1,695
Bread,	....	8	.046	608
Butter,	....	2	.001	451
Coffee,*	....	....	.010	417
Total,	....	....	.390	4,555
Dinner.				
Roast beef (chuck),	1	12	.277	1,435
Potatoes,	....	12	.014	233
Sweet potatoes,	....	12	.011	480
Bread,	....	6	.035	456
Butter,	....	2	.011	451
Rice,	....	4	.020	408
Eggs,	....	4	.030	160
Milk,	....	6	.012	122
Sugar,	....	2	....	232
Tea,	....	....	.010	410
Total,	....	....	.410	4,387
Supper.				
Bread,	....	12	.070	912
Butter,	....	2	.001	451
Bananas,	....	12	.006	225
Cake,	....	8	.032	838
Total,	....	....	.109	2,426
Total for 3 meals,	....	....	.909	11,268
Average for 1 person,	....	....	.227	2,817

*Coffee and tea in themselves have little or no nutritive value. In the menu, allowance is made for the milk or cream and the sugar that would ordinarily be added.

The American dietary standard for a man at moderate muscular work calls for 0.28 pound protein and 3,500 calories. It will be seen that the menu suggested above is insufficient; that is, more food must be supplied. For instance, cheese might be added for dinner, and pork and beans and milk for supper. The amounts of protein and energy which a sufficient quantity of these articles for four persons would supply are shown in the following table:

Food Added to Bring the Day's Menu up to the Dietary Standard.

Food Materials.	Weights.		Protein. Pound.	Fuel value. Calories.
	Pounds.	Ounces.		
Cheese,	....	4	0.069	536
Beans,	....	10	.141	1,005
Pork,	....	4	.005	918
Milk,	2	....	.066	650
Total amount added to menu,	....	....	.281	3,109

These additions would make the total protein 1,190 pounds and the total fuel value of 14,377 calories for four persons, or for one person, 0.298 pound protein and 3,599 calories. (For the sake of simplifying calculations no distinction is made between the amounts required by men and women.) These values are approximately the amounts required by the dietary standard.

Following the above method, the value of any menu chosen may be easily calculated. It should be borne in mind that approximate rather than absolute agreement with the dietary standard is sought. It is not the purpose to furnish a prescription for definite amounts of food materials, but rather to supply the means of judging whether the food habits of families accord in general with what research has shown to be most desirable from a physiological standpoint. If possible to devise menus which will furnish the requisite amounts of nutrients and energy at comparatively low cost.

Digestibility.

The value of a food is determined not alone by its composition, but also by its digestibility; that is, by the amount of it which the body can retain and utilize as it passes through the digestive tract. The term digestibility, as frequently employed, particularly in popular articles, has several other significations. Thus, to many persons

it conveys the idea that a particular food "agrees" with the user, i. e., that it does not cause distress when eaten. The term is also very commonly understood to mean the ease or rapidity of digestion, and one food is often said to be more digestible than another because it is digested in less time. However, the term digestibility is most commonly understood in scientific treatises on the subject to mean thoroughness of digestion. The digestibility of any food may be learned most satisfactorily by experiments with man, although experiments are also made by methods of artificial digestion. In the experiments with man both food and feces are analyzed. Deducting the amounts of the several nutrients in the feces from the total amounts of each nutrient consumed shows how much of each was digested. The results are usually expressed in percentages and spoken of coefficients of digestibility. From a large number of experiments with man it has been calculated that on an average the different groups into which foods may for convenience be divided have the following coefficients of digestibility:

Coefficients of Digestibility of Different Groups of Foods.

	Protein. Per cent.	Fat. Per cent.	Carbohydrates. Per cent.	Mineral matters. Per cent.
Animal foods,	98	97	100	75
Cereals and sugars,	85	90	98	75
Vegetables and fruits,	80	90	95	75

Making use of these figures, the digestible nutrients furnished by any food may be readily calculated. Thus, as shown by the table on composition above, sirloin steak contains 16.5 per cent. protein. One and one-half pounds would, therefore, contains 0.2475 pound protein, or in round numbers, 0.25 pound ($1.5 \times 16.5 = 0.2475$). As shown by the coefficients of digestibility quoted above, 98 per cent. of the protein of animal food is digestible. Therefore, 1.5 pounds sirloin steak would furnish 0.245 pound digestible protein ($0.25 \times 0.98 = 0.245$). The digestibility of the several nutrients in a given quantity of any food may be calculated in a similar way.

TABLE OF WEIGHTS AND MEASURES IN PENNSYLVANIA.

Wheat, per bushel, 60 lbs. Act March 10, 1818.
Barley, per bushel, 47 lbs. Act March 10, 1818.
Buckwheat, per bushel, 48 lbs. Act March 10, 1818.
Corn, per bushel, 56 lbs. Act April 16, 1845.
Rye, per bushel, 56 lbs. Act April 16, 1845.
Oats, per bushel, 32 lbs. Act March 30, 1897.
Potatoes, per bushel, 56 lbs. Act March 30, 1897.
Clover seed, per bushel, 60 lbs. Act June 26, 1895.
Onions, per bushel, 50 lbs. Act May 8, 1895.
Salt, coarse, per bushel, 85 lbs. Act March 10, 1818.
Salt, ground, per bushel, 70 lbs. Act March 10, 1818.
Salt, fine, per bushel, 62 lbs. Act March 10, 1818.
Salt, per barrel, evaporated, 280 lbs. Act March 24, 1877.
Bark, per cord, 2,000 lbs.
Bark, per ton, 2,000 lbs.

SPRAYING CALENDAR.

A Brief Outline of the Best Methods for the Protection of Crops From Insects and Fungi.

The utility of some condensed outline showing how and when to spray or otherwise treat fruit trees, shade trees, garden and field crops, and flowers, to prevent or check injuries by insects and plant diseases, is demonstrated by the number of such publications in other States. It is practically impossible, however, to include in such a paper, all of the foes of the agriculturist, and accordingly, only such are considered as have been found to be most likely to be present in Pennsylvania. At the same time, treatment for the injuries touched on here, will, in nearly every case, also control those not treated of, and, accordingly, in this way the ground will be nearly as well covered as though all such foes were considered in detail.

In all cases, treatment according to the directions here given must be applied with judgment, as no fixed rules can be given which will hold for every case, and an ignorant adherence to the directions without a knowledge of the particular conditions of the case, may fail to give the desired results. To obtain success in the control of insect and fungous foes, a knowledge of what the foe is, the best way to attack it, and when this attack is most effective, are necessary.

Any information desired on these subjects may be obtained by writing to the Division of Zoology, Department of Agriculture, Harrisburg, Pa., and the sending of samples of injury done, or of the insects or other foes causing the trouble will greatly aid in giving satisfactory answers.

Apple.

CODLING MOTH:

1. Paris green or Arsenate of Lead as soon as blossoms have fallen. 2. Repeat about ten days later. 3. Repeat in severe cases two weeks later. 4. Repeat about August 1 for second brood. See Report of Department for 1898.

BUD-MOTH:

1. Paris green or Arsenate of Lead as soon as leaf buds become green. 2. Repeat 1 just before blossoms open. 3. Repeat 2 after blossoms fall.

CANKER-WORM:

1. Paris green or Arsenate of Lead when caterpillars appear. 2. Same ten days later. 3. Repeat every ten days if needed.

TENT CATERPILLAR:

1. Destroy tents at night by torch. 2. If any escape, treatment for Codling moth will destroy them. See Report of Department for 1898.

PLUM CURCULIO:

1. Treatments 1 and 2 as for Bud Moth. See also under "Plum."

BORERS:

1. Cut out those already in the tree, in May. 2. Wrap several thicknesses of paper around the trunk and fasten, about the first of June, and leave till September; cover upper part of trunk and larger limbs with whitewash and a little Paris green, at the same time. See Report of Department for 1898.

OYSTER-SHELL SCALE AND SCURFY SCALE:

1. If severe, scrape the parts affected or spray with Whale Oil Soap before buds swell in spring. 2. Spray about the 5th of June, with Kerosene Emulsion. 3. Repeat 2 about June 25th. See Bulletin 43 of Department.

SAN JOSE SCALE:

See under "Peach."

SCAB:

1. Spray with Bordeaux mixture and Paris green just before the blossoms open. 2. Repeat 1 as soon as blossoms have fallen. 3. Repeat 1 about ten days later, and 4, if necessary two weeks later.

BITTER-ROT:

Same treatment as for Scab.

APPLE LEAF RUST:

1. Destroy all Red Cedar trees in the neighborhood of the orchard as this fungus passes a part of its life on the Cedars, causing the "Cedar Apples."

Apricot.

See Peach.

Asparagus.

ASPARAGUS BEETLES:

1. Destroy all volunteer asparagus, leaving only the shoots designed for market. 2. Let fowls run among the plants. 3. If serious, dust with fresh dry-slacked lime while dew is on. 4. Repeat 3 every day of ten days.

Bean.

ANTHRACNOSE OR POD SPOT:

1. Spray with Bordeaux mixture when first true leave has formed. 2. Repeat 1 often enough to keep leaves covered by the mixture till a week before eating pods. 3. Soaking the seed before planting, in ammoniated copper carbonate for an hour is a very effectual treatment.

LIMA BEAN MILDEW:

1. Burn all parts of the plant at once after harvesting the crop.

Beet.

RUST:

1. Spray with Bordeaux mixture as soon as it appears. 2. Remove and burn all affected leaves.

LEAF SPOT:

1. Use Bordeaux mixture when four leaves have appeared. 2. Repeat at intervals to keep the mixture on the leaves. 3. Burn the leaves as soon as the crop has been gathered.

Cabbage and Cauliflower.

APHIS:

1. Use Kerosene Emulsion when they appear. 2. Repeat when needed till plants begin to head. 3. After heading begins use hot water or tobacco water.

CABBAGE WORM:

1. Paris green or Arsenate of Lead when the caterpillars first appear. 2. Repeat about every ten days till heading begins. 3. After heading begins, use Kerosene Emulsion or hot water as often as may be needed. 4. Fresh lime applied while dew is still on is also a good method.

ZEBRA CATERPILLAR:

1. Destroy the caterpillars as soon as they appear, while they are yet in company. 2. Use Paris green when needed, till the head begins to form, or the "flower" appears in the case of cauliflower. 3. Hand picking or hot water when poisons cannot be safely used. See Report of the Department for 1898.

ROOT MAGGOT:

1. When the maggots are first noticed, make a small hole near the main root of the plant, pour in half a teaspoonful of Carbon Disulphide, and close up the hole. 2. Tarred paper cut to let the plant grow up through the centre but fitting closely to the stem and onto the ground is a good preventive method. See Report of Department for 1898.

HARLEQUIN CABBAGE BUG:

A recent addition to cabbage foes in Pennsylvania. A hard black bug with red or orange markings, nearly half an inch long when full grown. 1. Plant a trap crop of mustard early for the bugs to collect on and gather them from this or spray it with pure kerosene. 2. Gather the bugs and egg masses by hand. See Report of Department for 1898.

CLUB-ROOT:

1. Burn affected plants. 2. Strict rotation of crops. 3. Lime, 75 bushels to the acre, has been highly recommended as a preventive.

Carnation.

ANTHRACNOSE AND RUST:

1. Bordeaux mixture on first appearance. 2. Repeat, every two weeks till flowers appear. 3. After flowers appear, use ammoniacal copper carbonate every two weeks.

Celery.

CELERY CATERPILLAR:

1. Paris green while plants are small. 2. Later, hand picking, if necessary.

BLIGHT OR RUST:

1. Ammoniacal copper carbonate. 2. Repeat once a week. 3. Artificial shade is advantageous.

LEAF-BLIGHT:

Same as for Rust.

SOFT-ROT:

Chiefly in plants stored or banked in wet places. 1. Keep dry. Or 2. Place under pure water.

Cherry.

APHIS:

1. Kerosene Emulsion when they first appear. 2. Repeat every three or four days, if necessary.

SLUG:

1. Paris green or Arsenate of Lead. 2. Repeat if needed every ten or twelve days.

CURCULIO:

See under "Plum."

BLACK KNOT:

1. Cut off the branches six inches or more below the injured place and burn them. 2. Get your neighbors to do the same to their trees. United action is necessary if the disease is to be stamped out.

ROT:

1. Bordeaux mixture before blossoms open. The addition of Paris green at this time is a good plan. 2. Repeat, without Paris green, when the fruit has set. 3. Repeat 2 twice at intervals of one to two weeks.

LEAF BLIGHT:

Same as for Rot.

Chrysanthemum.

LEAF-SPOT:

1. Bordeaux mixture on first appearance. 2. Repeat every two weeks if needed.

Corn.

WIRE-WORMS:

1. Rotation of crops. 2. Late fall plowing, repeated for several years. 3. Kainit, 1,000 pounds per acre has been highly recommended. See Report of Department for 1898.

CUT-WORMS:

1. Trap by scattering bunches of fresh clover, dipped in Paris green over the field before planting. 2. Place such bunches along the rows, later. Caution: Keep fowls and stock away.

CORN WORM OR BOLL WORM:

1. Hand picking. 2. Late fall plowing. See Report of Department for 1898.

SMUT:

1. Cut out and burn all portions affected, as soon as discovered.

Cucumber and Squash.

STRIPED CUCUMBER BEETLE:

1. Netting till plants are well established or, 2. Powdered refuse tobacco around the stems, occasionally renewed. See Report of Department for 1898.

SQUASH BUG:

1. Burns vines immediately after gathering the crop. 2. Hand picking.

MILDEW:

1. Bordeaux mixture on first appearance. 2. Burn vines after gathering the crop.

Currant and Gooseberry.

CURRANT WORM:

1. Paris green or Hellebore when the worms first appear. 2. Re peat, using Hellebore every ten days or two weeks if needed.

STEM GIRDLER:

1. Cut off stem three inches below the girdled place and burn.

GOOSEBERRY FRUIT WORM:

1. Let fowls run among the plants. 2. Pick off and destroy injured fruit. 3. Rake up and burn the fallen leaves and rubbish near by, in the fall.

FOUR-LINED LEAF BUG:

1. Spray, in May, with Kerosene Emulsion, one part; water five parts.

LEAF-SPOT:

1. Spray with ammoniacal copper carbonate soon after leaves open. 2. Repeat with Bordeaux mixture every two weeks as long as needed. 3. Gather and burn fallen leaves in the fall.

MILDEW:

1. Spray with Potassium Sulphide solution (liver of sulphur) as the leaves begin to open. 2. Repeat every two or three weeks if needed.

Egg Plant.

LEAF-SPOT:

1. Bordeaux mixture as soon as plants are established in the field. 2. Repeat every two or three weeks till fruit is half grown. 3. Then use ammoniated carbonate.

Elm.

ELM LEAF BEETLE:

1. Spray with Paris green or Arsenate of Lead when leaves first open. 2. Repeat two weeks later. 3. Repeat if necessary.

TUSSOCK MOTH:

1. Gather and destroy the whitish egg masses in winter. 2. Repeat in July or August, before the eggs hatch and the caterpillars scatter. 3. If the caterpillars are feeding, spray with Paris green or Arsenate of Lead as often as needed.

Grape.

ROSE BUG:

1. Collect the insects by hand. 2. Bag the forming bunches of grapes. See Report of Department for 1898.

GRAPE VINE FLEE BEETLE:

1. Spray with Paris green or Arsenate of Lead as soon as seen. 2. Repeat every week if necessary.

GRAPE VINE LEAF HOPPER:

1. Dust the vines with insect powder or tobacco dust about the first of July. 2. Repeat one week later if necessary.

ANTHRACNOSE:

1. Brush the vines over with Sulphate of Iron and Sulphuric Acid solution before the buds open. 2. Repeat three or four days later. Do not use after the vines start growing.

DOWNY MILDEW, POWDERLY MILDEW:

1. Bordeaux mixture when leaves are fully opened. 2. Repeat about ten days before the flowers open. 3. Spray with potassium sulphide solution three weeks later if necessary.

BLACK ROT:

1. Bordeaux mixture as the buds open. 2. Repeat every two weeks if needed, till fruit is half grown; then use ammoniacal copper carbonate, repeating every week or two if necessary.

RIPE ROT:

1. Same treatment as 2 under black rot.

Hollyhock.

RUST:

1. Bordeaux mixture as leaves open. Repeat at intervals of ten days if needed.

Maples.

TUSSOCK MOTH:

See under "Elm."

COTTONY MAPLE SCALE:

1. Spray with Kerosene Emulsion early in June. 2. Repeat in two weeks if necessary.

Nursery Stock.

SUCKING INSECTS:

1. Kerosene Emulsion as soon as discovered. 2. Repeat in two weeks if necessary.

CHEWING INSECTS:

1. Paris green or Arsenate of Lead when discovered. 2. Repeat as may be needed.

FUNGOUS DISEASES:

1. Bordeaux mixture when leaves open. 2. Repeat every two weeks if needed.

Oats.

LOOSE SMUT:

Soak the seed five to ten minutes in hot water at 133 degrees F. This may be done some time before planting, if desired, and hasten sprouting besides destroying the Smut.

RUST:

No good treatment known.

Onion.

MAGGOT:

1. Put the onion bed some distance from the one of the preceding year. 2. Same treatment as for the cabbage root maggot.

MILDEW:

1. Burn all the tops in the fall. 2. Rotation of crops.

SMUT:

1. Burn all refuse in the fall. 2. Start the onions on land not used for onions the preceding year and transplant—a process which pays for other reasons also.

Peach, Apricot, Nectarine.

PEACH BORER:

1. Wrapping trunk as described for Apple Tree Borer. 2. Mounding up earth a foot or more about June 1st, and removing about September 1st. 3. Wash trunk and lower parts of limbs with whitewash and a little glue, with a tablespoonful of Paris green to each bucketful. One, 2 and 3 are alternate methods treatment. See Report of Department for 1898.

BLACK PEACH APHIS:

1. Dig refuse tobacco powder or stems, or Kainit into the ground about the roots. 2. Spray with Kerosene Emulsion when the Aphis appears above the ground.

CURCULIO:

See under "Plum."

SAN JOSE SCALE:

1. Keep trunk and limbs covered with whitewash from June 1st, till frost appears. 2. Spray with Whale Oil Soap, 1 lb. to 1 gallon of water, after the leaves are off in the fall. 3. Spray with Whale Oil Coap, 2 lbs. to 1 gallon of water, before the buds start in the spring. 4. Cut back and thoroughly prune infected trees after spraying and burn the prunings. 5. Destroy badly infested plants. See Bulletin No. 43 of Department.

PEACH LEAF CURL:

1. Spray with Copper Sulphate before buds open in spring. 2. Spray with Bordeaux mixture when leaves are half grown.

PEACH ROSETTE:

No good remedy.

BROWN ROT:

1. Spray with Copper Sulphate before buds open. 2. Bordeaux mixture before flowers open. 3. Repeat 2 every ten to fourteen days after fruit has set, until the fruit is half grown. 4. Repeat every five to seven days, using ammoniacal copper carbonate instead of Bordeaux mixture.

YELLOWS:

1. Destroy all affected trees by fire. 2. Dig out and burn roots also.

Pear.

BORERS:

See under Apple.

CODLING MOTH:

See under Apple.

PEAR MIDGE:

1. Apply 1,000 lbs. of Kainit per acre, to the ground beneath the trees about the middle of June.

PEAR LEAF MITE:

1. Spray in winter with Kerosene Emulsion, 1 part; water 6 parts.

PEAR PSYLLA:

1. Spray with Whale Oil Soap, 1 lb. to 1 gallon of water, in April, spraying only the trunk and larger branches.

SLUG:

See under Cherry.

SAN JOSE SCALE:

See under Peach.

LEAF BLIGHT OR FRUIT-SPOT:

1. Spray with ammoniacal copper carbonate as the leaves open. 2. Bordeaux mixture just before the blossoms open. 3. Repeat 2 after fruit has set, at intervals of two weeks as needed.

FIRE BLIGHT:

Cut off and burn affected parts, cutting at least a foot below where the disease shows.

SCAB:

See under Apple.

Plum.

CURCULIO:

1. Spray with Paris green or Arsenate of Lead before the flower buds open. 2. Repeat 1 soon after the blossoms have fallen. 3. Gather the insects by jarring onto cloths beneath the tree, at night and in the morning. 4. Gather and destroy fallen plums every day. 5. Let fowls run under the trees.

PLUM LECANIUM:

1. Kerosene emusion one part, water four parts, after leaves have fallen in the fall. 2. Repeat 1 in spring before the buds open.

SLUG:

See under Cherry.

BORERS:

See under Apple.

SAN JOSE SCALE:

See under Peach.

LEAF BLIGHT:

1. Bordeaux mixture when the leaves first appear. 2. Repeat 1 after the fruit has set, every two or three weeks till fruit is three-quarters grown. 3. Now use ammoniacal copper carbonate if needed, every two or three weeks.

BROWN ROT:

See under Peach.

BLACK KNOT.

See under Cherry.

Potato.

POTATO BEETLE:

1. Paris green or Arsenate of Lead as soon as insects are seen. 2. Repeat whenever needed.

POTATO STALK BORER:

1. Gather and burn all stalks after gathering the crop.

EARLY BLIGHT OR LEAF SPOT:

1. Bordeaux mixture when plants are half grown. 2. Repeat 1 every two or three weeks.

POTATO ROT:

1. Bordeaux mixture about the middle of July. 2. Repeat 1 every two weeks.

SCAB:

Soak seed potatoes in corrosive sublimate 1 ounce, water 8 gallons, for one and one-half hours before cutting them.

LATE BLIGHT OR MILDEW:

1. Bordeaux mixture when the disease appears. 2. Repeat 1 whenever needed.

Quince.

CURCULIO:

1. Jarring as for Plum Curculio.

LEAF BLIGHT:

1. Bordeaux mixture before flower buds open. 2. Repeat 1 when fruit has set, and every two or three weeks until fruit is three-quarters grown. 3. Ammoniacal copper carbonate later, if needed.

FIRE BLIGHT:

See under Pear.

Raspberry, Blackberry, Dewberry.

SLUG:

1. Paris green or Arsenate of Lead when insects first appear. 2. Repeat 1 two weeks later unless fruit is nearly ripe.

SNOWY TREE-CRICKET:

Cut off and burn twigs pierced, during the winter, to destroy the eggs in them.

ANTHRACNOSE:

1. Cut out all badly diseased canes. 2. Copper Sulphate solution before the buds open. 3. Bordeaux mixture after growth has commenced. 4. Repeat 3 every two or three weeks till fruit is two-thirds ripe.

ORANGE RUST:

1. Cut out and burn all diseased plants. 2. Get your neighbors to do the same.

Rose.

APHIS AND LEAF HOPPERS:

1. Kerosene Emulsion, strong soap suds or tobacco water as often as needed.

SLUGS:

Dust with quick lime.

RED SPIDER:

Syringe with clear water. If very abundant, Kerosene Emulsion.

BLACK SPOT:

Spray once a week with ammoniacal copper carbonate.

MILDEW:

1. Spray with Bordeaux mixture or ammoniacal copper carbonate as often as necessary. 2. In greenhouses, fumigate with sulphur.

RUST:

1. Destroy all affected portions. 2. Gather and burn dead leaves in the fall. 3. Ammoniacal copper carbonate after leaves open.

Strawberry.

SLUG:

See under Raspberry.

WEEVIL:

No good remedy.

LEAF BLIGHT:

1. Bordeaux mixture after the crop is gathered. 2. Repeat 1 when leaves open in the spring. 3. Repeat 2 just before blossoms open.

Tomato.

TOMATO WORM:

1. Hand picking. 2. Paris green or Arsenate of Lead, as needed, till fruit begins to turn in color.

CORN WORM:

See under Corn.

FLEA BEETLE:

Paris green or Arsenate of Lead as often as needed.

LEAF BLIGHT:

1. Bordeaux mixture as soon as disease is discovered. 2. Repeat 1 every week or ten days.

ROT:

Same treatment as for Leaf Blight.

Violet.

RED SPIDER:

See under Rose.

BLIGHT SPOT:

Bordeaux mixture when disease appears. Repeat every ten days when blossoms are not present. 3. Remove affected leaves.

Wheat.

HESSIAN FLY:

1. Plant a trap piece about August 1st. 2. Plow under about September 10th, and plant main crop after September 20th. See Report of Department for 1898.

WHEAT MIDGE:

1. Plow deep soon after harvest. 2. Carefully sweep up and burn chaff and "tailings" after threshing. See Report of Department for 1898.

APHIS:

No good treatment. See Report of Department for 1898.

FORMULAS.

PARIS GREEN.

	Parts.	Per bbl.
Paris green,	1 lb.	$\frac{1}{4}$ lb.
Quick lime,	1 lb.	$\frac{1}{4}$ lb.
Water,	200 gals.	50 gals.

This is too strong for the peach, where $2\frac{1}{2}$ oz. each of Paris green and quick lime should be used instead of $\frac{1}{4}$ lb. Keep the mixture well stirred while using. To make it, mix the Paris green and the lime and add enough of the water to slake the lime, stirring while hot, then add the rest of the water.

Good Paris green gives far better results than the cheaper grades.

ARSENATE OF LEAD.

This is a comparatively new insecticide, its value having only become known within a few years. It has several advantages over either Paris green or London purple, the chief ones being that it remains more easily suspended in water, thus requiring much less stirring up during the spraying; that it shows plainly on the leaves, indicating where the spray has reached, and where it has not; and that large proportions may be used without danger of burning the leaves. It is, therefore, especially useful where the leaves are particularly sensitive.

	Parts.	Per bbl.
Arsenate of soda, ...	4 oz.	2 oz.
Acteate of lead, ...	11 oz.	$5\frac{1}{2}$ oz.
Water, ...	100 gals.	50 gals.

These two substances, when placed in the water dissolve rapidly, and combine, forming a fine white sediment which is the Arsenate of Lead. It can also be purchased ready for addition to the water, but it is usually better when prepared as above. It is as cheap, or in the end cheaper than Paris green, as it stays much longer on the trees before being washed off by the rains. Some persons advise the addition of two quarts of molasses to each hundred gallons of the water, but the benefit to be derived from this is questionable.

WHALE OIL SOAP.

	Parts.	Per bbl.
Whale oil soap, ...	2 lbs.	80 lbs.
Water, ...	1 gal.	40 gals.

This is much stronger than Kerosene Emulsion and should only be used during winter, when the trees are not growing. It can be used for insects which cannot be killed by Kerosene Emulsion. In spraying for the San José Scale in the fall (see under Peach), it should be used at the rate of one pound to a gallon of water; in the spring before the buds open, or for winter work, it can be used as above given.

KEROSENE EMULSION.

	Parts.	Per bbl.
Hard soap (shaved fine), ...	½ lb.	1 lb.
Water, ...	1 gal.	2 gals.
Kerosene, ...	2 gals.	3½ gals.

Dissolve the soap in the water, which should be boiling, and while it is very hot pour the suds into the kerosene; then churn it with a spray pump till it changes to a creamy mass, and then to a soft, butter-like substance. This should keep for some time. When it is desired to use it, add one quart of it to nine times as much water, mix well, and spray the plants. The water should be soft water, or else have some soda added to it.

For the Four-lined Leaf bug take one part of the Emulsion and five parts of water.

TOBACCO WATER.

Place tobacco stems or refuse tobacco in enough hot water to cover; let stand several hours. Take one part of this to three or four of water, and spray over the plants.

CARBON DISULPHIDE.

To be obtained of druggists at about thirty cents per pound. In using, avoid bringing it near fire or even hot steam pipes, as it catches fire easily. Avoid breathing it also.

HELLEBORE.

May be applied either as a powder or in water. If used as a powder it may advantageously be mixed with an equal amount of flour, which causes it to remain better on the leaves. For use with water one ounce of fresh Hellebore is mixed with three gallons of water.

INSECT POWDER.

Insect powder is sometimes sold under the names of Pyrethrum and Bubach. It may be applied as the dry powder, when the plant is wet with dew. It may also be mixed with flour and used in that way, or it may be used in an alcoholic solution as follows:

Insect powder (by weight), ...	1 part.
Alcohol (by weight), ...	4 parts.

Put the two in a tight vessel and leave there for eight days, shaking it occasionally; then filter and spray over the plants.

It should be remarked that Insect Powder is only of value when fresh and of full strength. Unfortunately it is difficult to obtain it fresh, and much of it is so adulterated as to be practically worthless.

LIME.

Lime is often of much value as an insecticide, either as whitewash, sometimes with enough Paris greed added, to give it a slight greenish tinge, or as quick lime to be dusted onto the insects. When used in the preparation of Paris green it is added to combine with the free arsenic present, which would burn the leaves, if left uncombined.

NORMAL OR 1.6 PER CENT. BORDEAUX MIXTURE.

Copper sulphate (blue vitriol), ...	6 pounds.
Quick lime (good stone lime), ...	4 pounds.
Water, ...	50 gallons.

Dissolve the copper sulphate by putting it in a bag of coarse clothing and hanging this in a vessel containing 4 to 6 gallons of water. Use an earthen or wooden vessel. After the copper sulphate is dissolved, dilute with water to 25 gallons. Slake the lime and add 25 gallons of water. Mix the two and keep thoroughly stirred while using. If the mixture is to be used on peach foliage, it is advisable to add two pounds more of lime to the above formula.

BORDEAUX MIXTURE AND PARIS GREEN.

Mix 4 ounces of Paris green as prepared above, with 50 gallons of normal Bordeaux mixture.

AMMONIACAL COPPER CARBONATE.

Copper carbonate, ...	4 ounces.
Ammonia, ...	3 pints.
Water, ...	45 gallons.

Make a paste of the copper carbonate with a little of the water. Dilute the ammonia with 7 or 8 times its bulk of water. Add the paste to the diluted ammonia and stir until dissolved. Add enough water to make up to the 45 gallons. Let it settle and use the clear blue liquid only. Do not make this up long before using as it loses its strength on standing. It is used when the fruit is so nearly ripe that Bordeaux mixture would produce stains if it were used.

POTTASSIUM SULPHIDE SOLUTION.

(Liver of Sulphur.)

Potassium sulphide, ...	½ to 1 ounce.
Water, ...	1 gallon.

Particularly good for surface mildews but loses its strength upon standing, so should be used at once after making.

SULPHATE OF IRON AND SULPHURIC ACID SOLUTION.

Water (hot), ...	100 parts.
Iron sulphate (green vitriol), ...as much as the water will dissolve.	
Sulphuric acid (commercial), ...	1 part.

Make the mixture with much care, as heat is produced. Use on plants when dormant only, applying with brushes or sponges, as the solution is injurious to spraying machinery.

CORROSIVE SUBLIMATE.

This dissolves slowly and but slightly in water. The process may be hastened by heating the water.

GENERAL REMARKS.

In the treatment of fruits by sprays it should be remembered that the substances used are in almost every case poisonous. It is accordingly necessary to avoid spraying at times when fruit is nearly ripe, both on account of the possibility of placing poison on the fruit just before it is picked, and because of the danger of staining it, as would be the case if certain solutions were used.

Spraying solutions often need to be carefully strained, and it is advisable to do this when putting them into the barrel or other receptacle from which they will pass through the spray pump. Nozzles will clog from larger lumps in the fluid, and care should be taken to avoid this as far as possible. Every pump should have an agitator attached to keep the mixture well stirred in the barrel, and it should not be expected that the same nozzle will do first class work with every spraying mixture given. Some nozzles are especially adapted to one kind of spray, and others to other sprays. Above all, an intelligent knowledge of what is causing the injury, and exactly how and when to take the proper steps to control it, should be one of the ingredients added to every formula here given.

INDEX BY AUTHORS.

L.

M.

P.

R.

S.

V.

W.

INDEX BY SUBJECTS.

65—6—1902

D.

E.

F.

R.

S.

T.

W.

Z.